PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 150—No. 3886. LONDON: FRIDAY, JULY 5, 1940. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 2½d.

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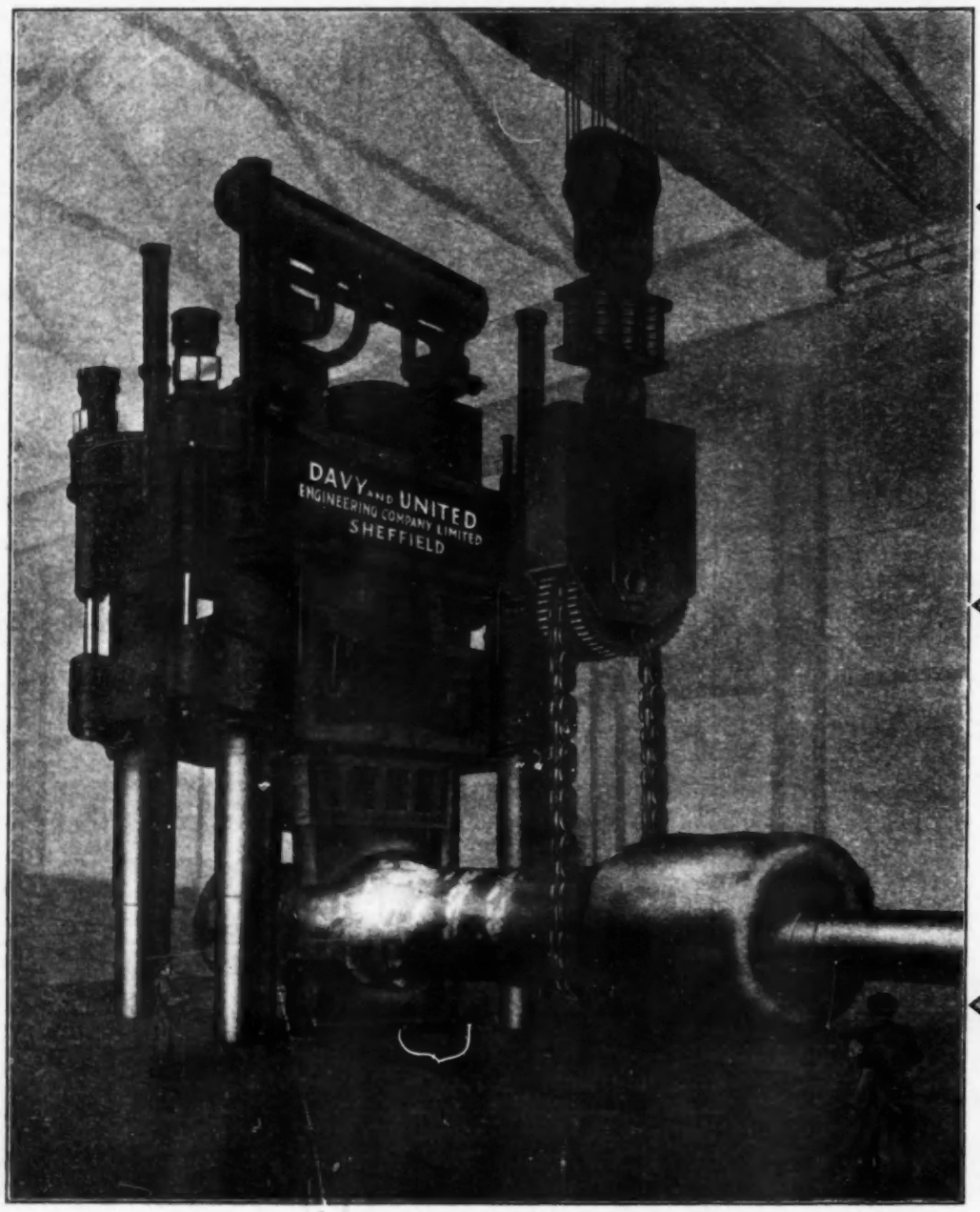

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ENGINEERING.

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS, U.S.A.

THE road bridge which has been built to carry State Highway No. 87 across the Neches River, between Port Arthur and Orange, in the State of Texas, has many points of unusual interest. The channel at the point where the bridge crosses is about 1,000 ft. wide, flat marshy land extending on each side up to a width of some 5 miles. The natural depth of the channel is approximately 20 ft., but during the past fifteen years the Corps of Engineers of the United States Army has dredged a navigable channel about 600 ft. wide and 32 ft. deep. The purpose of this has been to provide passage for ocean-going tankers which serve the oil refineries in the neighbourhood of Beaumont, situated 15 miles upstream from the bridge. The accommodation of this traffic has required a passage 600 ft. wide under the bridge and a head clearance of 176 ft. above normal water level. These conditions have necessitated the building of a structure of unusual height for a bridge of its class and the provision of approaches of great length, while interesting foundation problems have had to be solved. The total length of the bridge and its approach viaducts is 7,752 ft.

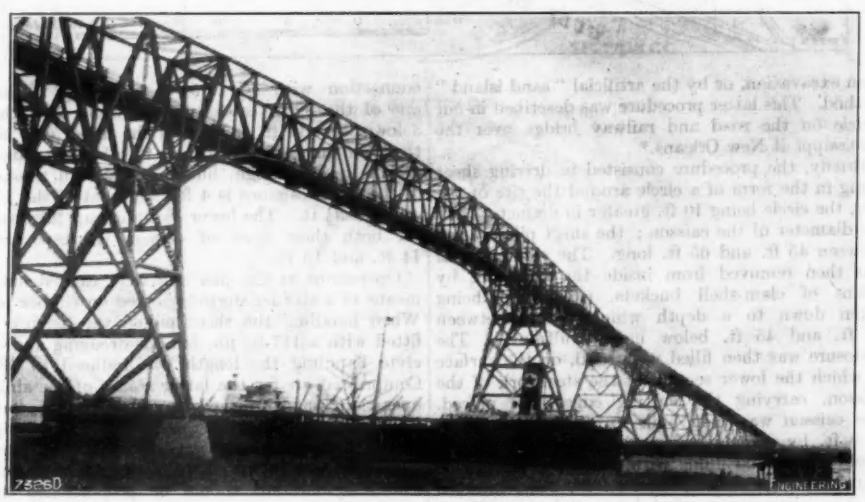


FIG. 1. COMPLETED CENTRE SPAN.

Prior to the construction of the bridge, there was a break in Highway No. 87 at Neches River, which was crossed by a ferry, known as Dryden Ferry. This was operated by Jefferson County, which is the division of the State of Texas, lying to the south of the bridge. The operation of this ferry cost 30,000 dols. a year. The traffic had gradually grown until it averaged 600 vehicles a day and there was but little delay on week-days. On Saturdays, Sundays and holidays, however, when two ferry boats were in operation, each capable of accommodating twelve vehicles, serious delays were not uncommon. The position of the bridge in relation to the road, river and surrounding towns is shown in the map reproduced in Fig. 2, on page 2. A number of schemes for crossing the river at Dryden Ferry, or in its vicinity, have been proposed and studied in the past. These included a tunnel; but the first proposal which appears to have been considered seriously was one for the construction of a double-leaf bascule bridge, with 300 ft. horizontal clearance at the piers. An application to build a bridge of this type was submitted to the Corps of Engineers of the United States Army, which has jurisdiction over all matters affecting navigable rivers in the country. This proposal was, however, faced by such vigorous opposition from the Beaumont navigation interests that the War Department refused permission for the building of any type of bascule bridge. As already mentioned, it is necessary for ocean-going vessels to have free access to Beaumont. These are almost exclusively concerned with the shipment of petroleum products and, in general, return to the port in ballast. Some vessels are, however, employed on the import of mechanical equipment and steel for the refining companies.

After the rejection of the project for a bascule bridge, the War Department advised that if the site for a bridge were moved upstream to a point where there was a relatively straight section of the river, approval would be given for a viaduct-type bridge if the headroom above water level were made 135 ft. and the horizontal clearance not less than 500 ft. In view of this ruling, application was made for approval of a design of this type providing vertical clearance of 155 ft. and horizontal clearance of 600 ft. In spite of protests from the navigation authorities, this design was passed by the War Department. The matter, however, became an issue of such heated controversy between Beaumont and Port Arthur that, before agreement was reached between these two towns to promote the necessary legislation, the vertical clearance had to be increased to 176 ft., the horizontal clearance remaining at 600 ft. The main part of the construction cost was provided by a grant of 1,141,742 dols. by the Public Works Authority, an additional sum of 750,000 dols. being provided by a bond issue by Jefferson County.

The estimated cost of the bridge was some 2,500,000 dols., and a Federal offer to the State of Texas and Jefferson County, covering the difference between this figure and the sums already mentioned, was made from Washington on September 14, 1935. When this offer was accepted, on October 1, 1935, the Highway Commission was notified that it was conditional on plans and specifications being prepared and a contract awarded by December 15 of the same year. This provision left a very brief period for the necessary preliminary work on a structure of quite unusual design. Messrs. Ash-Howard-Needles and Tammen, of New York, were appointed consulting engineers for the project and began work on the plans on October 17. On November 13, specifications and plans were submitted for approval by the State of Texas Director of the Public Works Authority and tenders for the building of the sub-structure units were invited on November 24. The contract was awarded to the Union Bridge and Construction Company, of Kansas City, on December 11. Instruction to proceed with the project generally were issued on March 3, 1936.

The bridge crosses the river approximately at right angles, and to meet the requirements of the War Department it is so placed that there is a straight section of river, half-a-mile long, on each side of the site. The presence of marshes on each bank of the river, extending to a total width of some five miles, created unusual difficulties in connection with setting out and the provision of reference points. Even after construction had been started, considerable trouble was experienced in making checking observations on the various parts of the structure. In connection with the preliminary surveys, which were made in 1934, test borings were made at about 100 ft. from the bank on each side of the river and at a number of points. These borings showed the existence of a semi-liquid marsh deposit some 30 ft. to 40 ft. thick, below which were courses of water-bearing sand from 50 ft. to 60 ft. thick. Lying under this soft material, a stratum of hard brown clay was found at all test points on the south bank of the river and at a number of points on the north bank. The test borings were made by driving a 4-in. diameter pipe into the marsh and sand and pumping out the entrapped material. When the hard clay was reached, cores were obtained by driving a 2-in. pipe. It was established by these boring tests that the pier foundations for the main part of the structure would have to be taken down to a depth of about 100 ft. below mean water level in the Gulf of Mexico.

These preliminary boring tests served as a basis

for the preparation of the original specification and the cost estimates. As, however, the Federal grant covered the construction of a bridge of greater under-clearance than had at first been contemplated, so that longer approaches were necessary in order to maintain a suitable gradient, it was necessary to undertake further borings when the constructional drawings were being got out. These borings were carried out in the soft material by sinking a pipe as before, but augers were used to obtain cores from the stiff clay. The later tests indicated that the clay strata lay somewhat deeper than had originally been supposed, and modifications had to be made hastily to the substructure design in order to suit the date limit of December 15, which had been set by the Public Works Authority. Investigations carried out on the stiff-clay samples indicated that the material had a bearing value of 3 tons per square foot under normal conditions of loading and 4·5 tons per square foot under extreme conditions. An interesting feature of the test-boring operations was the use of a light-type motor vehicle mounted on wheels carrying large flat wooden shoes for transporting the boring equipment across the marsh. This type of vehicle, which is known in Texas as a marsh buggy, was illustrated and described in our columns in September, 1937.* The machine dealt with at that time, however, was carried on large balloon pneumatic tyres, instead of wheels with wooden shoes.

The bridge, of which a general view showing the centre span and one of the approaches is given in Fig. 1, on page 1, is of symmetrical design on each side of the river. The bridge proper is of the cantilever type with a central suspended span, 400 ft. long. The main piers are at 680-ft. centres, and the cantilever arms forming the adjacent spans are each 374 ft. long. Each approach, beginning from the river, consists of two 300-ft. truss spans; two groups each made up of three truss spans, the centre one of which for the first group is 170 ft. long and the outer spans 149 ft. long, the corresponding figures for the second group being 150 ft. for the centre span and 171 ft. for the outer; two truss spans, respectively 149 ft. and 170 ft. long; fifteen 60-ft. spans formed from joists; and twelve reinforced-concrete spans varying between 32 ft. 9 in. and 30 ft. 9 in. long. The total length of the structure, as previously mentioned, is 7,752 ft. The grade of the approaches is 5 per cent. and the roadway is 22 ft. 6 in. wide between the curbs. There is an 18-in. curb on each side of the road.

Much consideration was given to the question of the foundations, particularly those for the main piers, and an attempt was made to design large concrete piers with bases sufficiently wide to resist the overturning moment during wind storms, which are very violent in the district. It was found, however, that the base of a structure of this kind would have had to be so large that the proposal was not economically practicable. It was finally found necessary to adopt low pier units supported on independent caissons and carrying the legs of triangular steel towers. One of these low piers is to be seen in the foreground of Fig. 1. A similar type of foundation is used for the three piers on each side of the bridge, the total number of caissons used being sixteen. These are all cylindrical, there being four of 32-ft. diameter, four of 22-ft. diameter, and eight of 18-ft. diameter.

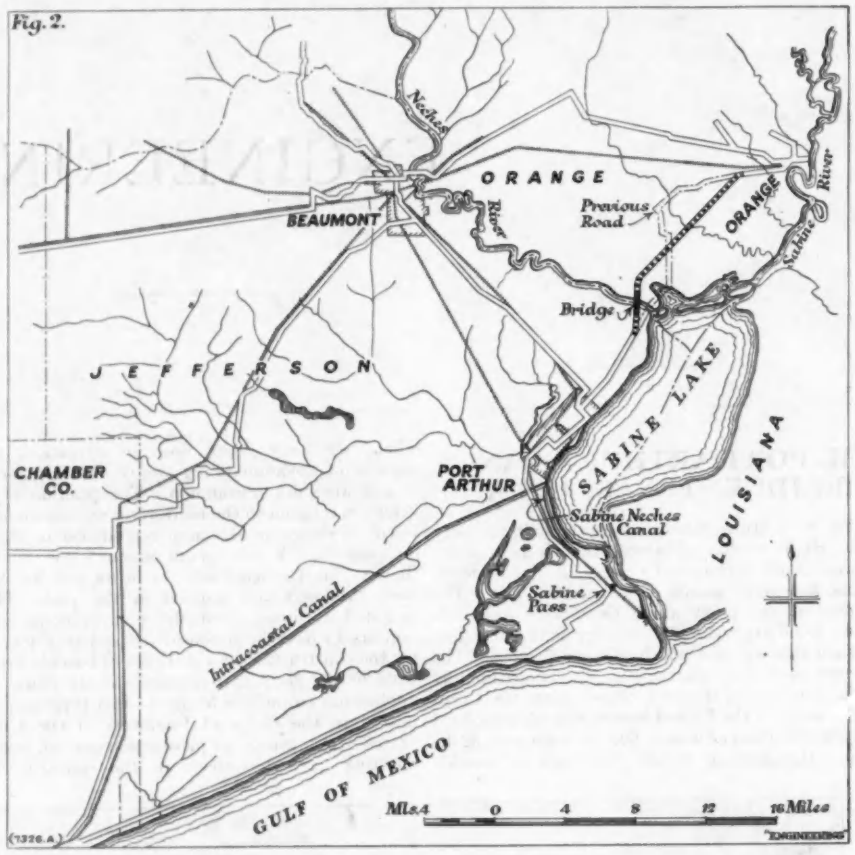
Drawings of one of the largest pier units are reproduced in Figs. 3 to 8, opposite. It consists of a steel frame filled in with concrete to form a cylinder 32 ft. in outside diameter with walls 5 ft. thick. As will be clear from Figs. 5 to 8, the frame is plated throughout its length, with $\frac{3}{8}$ in. plates outside and $\frac{1}{4}$-in. plates to form the inner face. The plates are secured to angle-iron rings spaced 3 ft. apart, the inner and outer rings being braced and connected together by $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{1}{2}$ in. cross angles, arranged in the manner shown in Figs. 3 and 4. The plates, which were 9 ft. wide, covering three ring sections, were lapped at the joints. The arrangement of the cutting edge, which is formed from a $\frac{3}{4}$-in. plate, 12 in. wide, is shown in Fig. 4.

The pier units were sunk either by dredging in

* ENGINEERING, vol. 144, page 27(1937).

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS.

Fig. 2.



open excavation, or by the artificial "sand island" method. This latter procedure was described in our article on the road and railway bridge over the Mississippi at New Orleans.*

Briefly, the procedure consisted in driving sheet piling in the form of a circle around the site of the pier, the circle being 10 ft. greater in diameter than the diameter of the caisson; the sheet piles varied between 45 ft. and 65 ft. long. The soft material was then removed from inside the enclosure by means of clam-shell buckets, excavation being taken down to a depth which varied between 30 ft. and 45 ft. below mean Gulf level. The enclosure was then filled with sand, on the surface of which the lower section of the steelwork of the caisson, carrying the cutting edge, was placed. The caisson was then built up in successive lifts of 9 ft. by placing and securing one of the 9-ft. steel sections and filling with concrete. As will be seen from Figs. 5 to 8, the concrete was reinforced by 1-in. diameter vertical bars pitched at 12 in. centres, arranged close to both the inner and outer faces. Horizontal reinforcement, consisting of rings made from 1 in. bar and spaced $9\frac{3}{4}$ in. apart, was also provided. As the caisson sank, the sand was removed from the inside by buckets operated from a steel derrick. Sinking was assisted by means of a high-pressure jet of water applied round the cutting edge.

When the caisson reached the hard clay, the upper end was completed by the conical concrete cap and air lock, which are shown in Fig. 5. Excavation then proceeded under air pressure. When the caisson was in its final position, its bottom was closed by a reinforced-concrete seal 17 ft. thick. This seal was placed in the dry under air pressure, it being necessary to employ a pressure of 48 lb. per square inch during this operation and for the last few feet of the sinking procedure. A solid concrete shaft was then built on top of the caisson to carry the steel columns supporting the superstructure. The interior of the caisson was allowed to fill with water. In

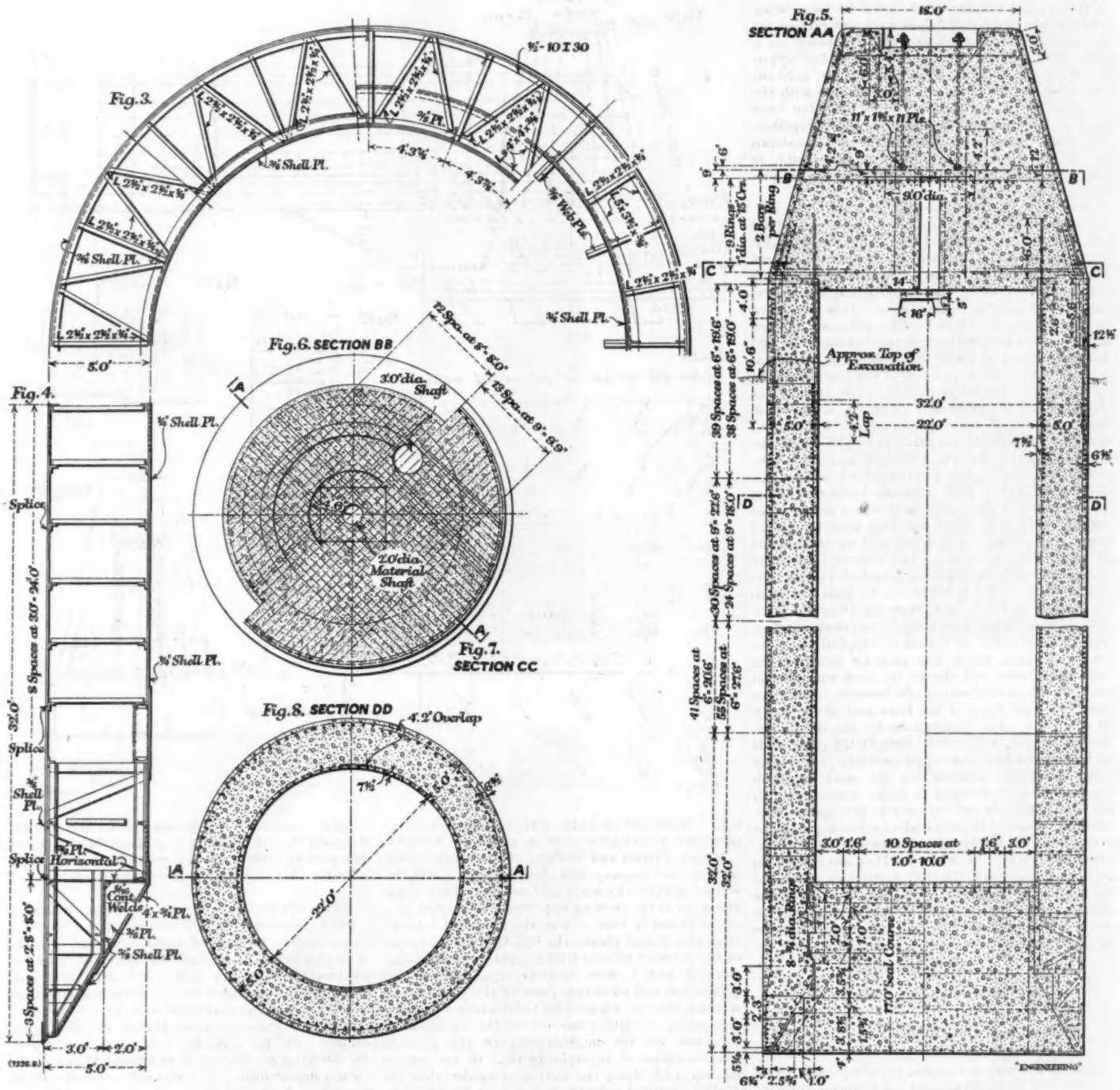
* ENGINEERING, vol. 142, page 2 (1936).

connection with Figs. 5 to 8, which illustrate one of the 32-ft. caissons, with walls 5 ft. thick, a lower seal 17 ft. thick, and the upper cap 25 ft. thick, it may be said that the smaller caissons are of similar design, but that the wall thickness of the 22-ft. caissons is 4 ft., and that of the 18-ft. caissons $3\frac{1}{2}$ ft. The lower seal and cap thicknesses for both these sizes of caisson is, respectively, 14 ft. and 16 ft.

Operations at the pier site were carried out by means of a stiff-leg derrick carried on timber piles. When handling the sheet piling, the derrick was fitted with a 117-ft. jib, but for dredging and concrete handling the length was reduced to 93 ft. Compressed air for the latter stages of the sinking operation was furnished from a floating steam-driven plant. Concrete was delivered to the pier sites in buckets which were transported in barges. The specification for the concrete work required that the materials should be proportioned by a weight-batching device. The mixing plant, a 1-cub. yard capacity Smith mixer, was erected on piles off-shore from a spoil bank, on the south side of the river, which had been formed during the dredging of the navigable channel. Cement and aggregate were carried to the plant in barges and unloaded into overhead bins by a crane carried on piles. They were delivered to the mixer by a cable-operated automatic dump car. The mixer was mounted high enough to allow the concrete to be delivered by gravity to dump buckets carried in steel barges. Each barge carried five 1-cub. yd. bottom-discharging buckets. These were lifted by a derrick boom from the barge at the point of deposit. Approximately 25,000 cub. yd. of concrete were mixed at this plant, out of a total of 32,000 cub. yd. used in the whole of the bridge foundations. The large main piers each involved the placing of 2,500 cub. yd. of concrete; of this, about 300 cub. yd. was placed in the bottom seal under air pressure. A rather stiff mix was used and pneumatic vibrators were necessary to ensure proper consolidation.

As already indicated, the local conditions imposed considerable difficulties in connection with setting-out and checking. The survey reference

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS.



points for the main piers required special triangulation owing to the presence of the spoil dump and the fact that the river was 1,000 ft. wide at the bridge site. Two base lines and two independent sets of triangulation were established, one forming a check on the other. Each base line was approximately 1,100 ft. long, and each was checked a number of times to within $\frac{1}{10}$ in. During measurement, the tape was supported on stakes set with the tops level and spaced 25 ft. apart. In the triangulation work, the closure of the triangles was made to within one second by repeated reading of angles. The distances between the two systems of triangulation showed a variation of $\frac{1}{4}$ in., and this was considered sufficiently accurate for the purpose of staking out the structure. Two independent sets of reference points were set for each pier, so that the centre of the caisson might be located by the three-line intersection method. Daily check readings were taken during the sinking of the caissons, elevations being taken at four points. After a reading had been taken at one reference point, the position of the caisson was determined by level readings at other points, and the top and bottom positions were checked against the plan position.

The substructure of the approaches, where the shorter spans are used, is supported on piers of the pedestal type, which, in turn, are carried on untreated timber piles. The latter vary in length from 50 ft. to 80 ft., the exact length required in each case being determined by driving test piles. Drawings of one of the reinforced-concrete pedestal piers, which are simple structures, are reproduced in Figs. 9 to 11, on page 4. The bottoms of the pedestals are placed 4 ft. to 5 ft. below mean Gulf level and the cut-off elevation for the piling is approximately 2 ft. 6 in. below Gulf level. The design of the superstructure required that the piling should be driven on a batter of approximately 5 in. per foot, to resist transverse wind forces during hurricanes. This disposition of the piles is indicated in Figs. 9 and 11. A plan of the top of the pedestal showing the position of the anchor bolts and retaining slots for the tower is given in Fig. 12. A section showing the reinforcement of the lower part of the pedestal block is given at the left-hand side of Fig. 13, the right-hand side showing a characteristic pole socket in the base. Incidentally, it may be said that, throughout the whole of the bridge, the effect of the force of the wind exercised a greater influence on the design of the substructure than on that of the superstructure. The pedestal-type piers support the steel columns in such a position that their lower ends are above extreme flood level and well clear of the marsh.

The soft marshland, extending on both sides of the river for several miles, imposed unusual diffi-

culties in connection with the transport of material and equipment. In order to overcome these, as far as possible, a construction canal, 60 ft. wide, 5 ft. deep, and 3,600 ft. long, was cut on the south side of the river, a similar canal, 3,400 ft. long, being made on the north side. This work was carried out by means of a dragline excavator mounted on a barge and operating a 2-cub. yd. bucket. Spur canals, at right angles to the main canals, were cut near to river banks for use in connection with the construction of the approach piers. Farther back from the river, where the piers are closer together, the canal was run close alongside the piers, as shown in Fig. 14, on Plate I. Mud-box cofferdams, as shown in this figure, were used to close off the pier sites.

Messrs. The Austin Bridge Company, the sub-contractors for all the approach piers carried on pile foundations, designed and built an ingenious crane-operated pile-driver mounted on a steel barge 40 ft. wide and 56 ft. long. This machine, which was navigated along the construction canal, was used for driving the inclined piles. It is illustrated in Figs. 15 and 16, Plate I. Two A-frames, inclined forward, were mounted on the front of the barge and were connected at their top ends by a horizontal beam made from a piece of 18-in. tubing. The frames were also connected by cross bracing, as shown in the illustrations. Mounted on the beam there was an 85-ft. telescopic frame, which supported the pile in position during driving and also carried the steam pile hammer. The telescopic frame could be swung into any angular position over a wide range, and had a travel of 25 ft. along the horizontal beam. At the stern of the barge there was a steam crane with a 65-ft. jib. This was also used to control the operation of the pile driver and the movements of the telescopic frame. The control leads were carried through pipe guides attached to the telescopic frame. One of these can be seen clearly in Fig. 15. The frame was traversed along the horizontal beam by leads operated by two deck winches. The oil-fired boiler of the crane supplied steam to its own engine, which was used for swinging the telescopic frame, and also to the deck winches and the 5,000-lb. double-acting pile hammer. Outrigger pontoons were fixed at the front end of the barge to steady it. The foundations for the reinforced-concrete spans, which were used at the outer ends of the approaches, were approximately of the same form as those employed for the steel approach spans, but were arranged to make connection with the concrete columns by which the spans were carried. Some of these foundation blocks, with the connecting reinforcing steel projecting from them, are shown in Fig. 17, Plate I. They are carried on inclined piles. Approximately 1,580 piles, of lengths ranging from 70 ft. to 86 ft., were used for the approach piers. About half of these were of Douglas fir, brought by rail from Oregon; the remainder were of Southern pine, obtained from local sources.

(To be continued.)

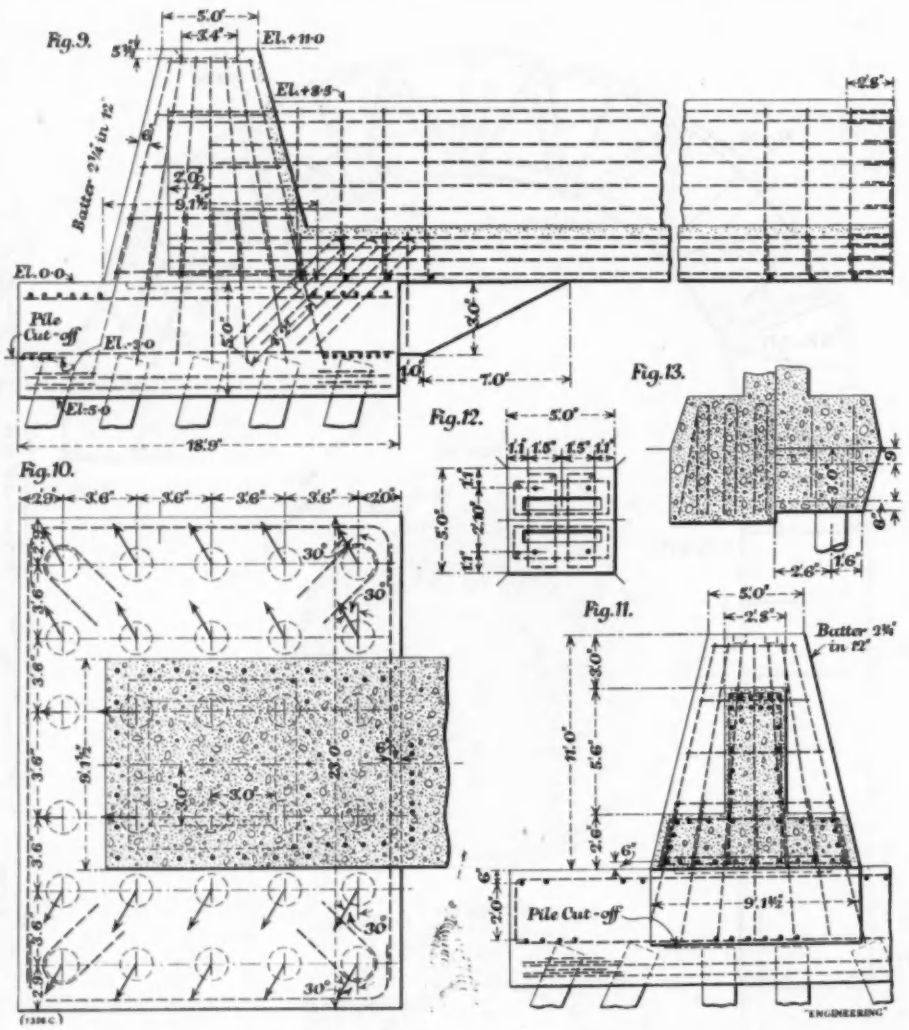
LITERATURE.

Reports of the Progress of Applied Chemistry. Vol. XXIV. 1939. London: The Society of Chemical Industry. [Price 12*s.* 6*d.* net.]

THIS annual survey of the developments which have taken place in applied chemistry during the year under review is valuable as a permanent record of chemical activity. The various sections have been prepared by eminent authorities on the subjects discussed, and prominence is given to any outstanding advancements which have occurred. This volume maintains the high standard of those published in previous years. A section on plastics, first introduced in 1938, is again included. The section dealing with plant and machinery is contributed, on this occasion, by Mr. M. B. Donald, of University College, who refers to the chief advances in heat transmission, concerned with the influence of surface chemistry and physics on the phenomena of boiling and condensation, to the effect of modern researches on aerodynamics in opening up new fields of work on diffusional processes, and to the progress recorded in the development of the "threshold" treatment of water with sodium hexametaphosphate to eliminate calcium-carbonate deposits.

Messrs. Parrish and Snelling, of the South Metropolitan Gas Company, have been entrusted with the section devoted to acids and alkalis. They draw attention to the growing importance of sulphur as a raw material in time of war, the increased activity of sulphuric-acid plants, the fact that modifications of the chamber process tend towards more intensive working and a more definite separation of the production and oxidation parts of the process, and mention that the demand for fertilisers in a granular non-caking condition has led to the evolution of processes for the improvement of the physical characteristics of superphosphate. In the section dealing with dyes, the authors consider that the British chemical industry is in a considerably more favourable position to-day than in 1914, and that in no branch is the contrast greater than in the dyestuffs industry. This country is now independent of foreign manufacturers for essential colouring matters. The year 1939 was characterised by great activity in the study of new synthetic fibres, resembling the natural protein fibres, and there is now produced on a commercial scale a synthetic polyamide—Nylon—as a substitute for silk. It resembles the natural fibre in most of its properties and is a triumph for the organic chemist in the search for truly synthetic fibres. The increasing importance of synthetic materials designed as substitutes for, or to improve on the performance of, natural rubber in various directions is well evidenced by the amount of literature devoted to the subject. There is now little doubt that synthetic rubber of certain types could at any time satisfactorily replace the natural material. How soon synthetic rubber-like products will be able to compete economically with raw rubber is a matter of conjecture, but the development of other synthetic chemicals to replace natural products in past years indicates that this time will eventually arrive.

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS.



Training Procedure. By FRANK CUSHMAN. London: Messrs. Chapman and Hall, Limited. [Price 12*s.* net.]

THE intensive training of works personnel of little or no experience, to the end that they may attain a serviceable proficiency within a limited field and in the shortest possible time, is a branch of industrial education that has developed to a greater extent in the United States than in British manufacturing centres. At the present time, however, many British firms are faced with this problem in a particularly urgent form, and it is possible that the direct outlook and incisive (if sometimes colloquial) style of this American textbook may assist them in framing an instructional policy designed primarily to achieve quick results. It is true that the author limits his scope to the problems of training employed personnel, with the principal object of improving the performance of work; but, while these are not quite the same as the problems arising with completely raw and uninstructed labour reserves, many of the general principles are either directly applicable in this case also, or can be used as a guide in formulating an *ad hoc* programme. Like so many works on industrial organisation, the book has a tendency towards the employment of words that border on jargon, but this need not deter the discriminating reader. A section is appended, dealing with the selection and instruction of the instructors themselves. The examples given are not exclusively drawn from engineering or even from manufacturing practice, but in general, they present a clear picture of the essentials.

THE PORT ARTHUR-ORANGE RIVER BRIDGE OVER THE NECHES RIVER, TEXAS, U.S.A.

(*For Description, see Page* 1).

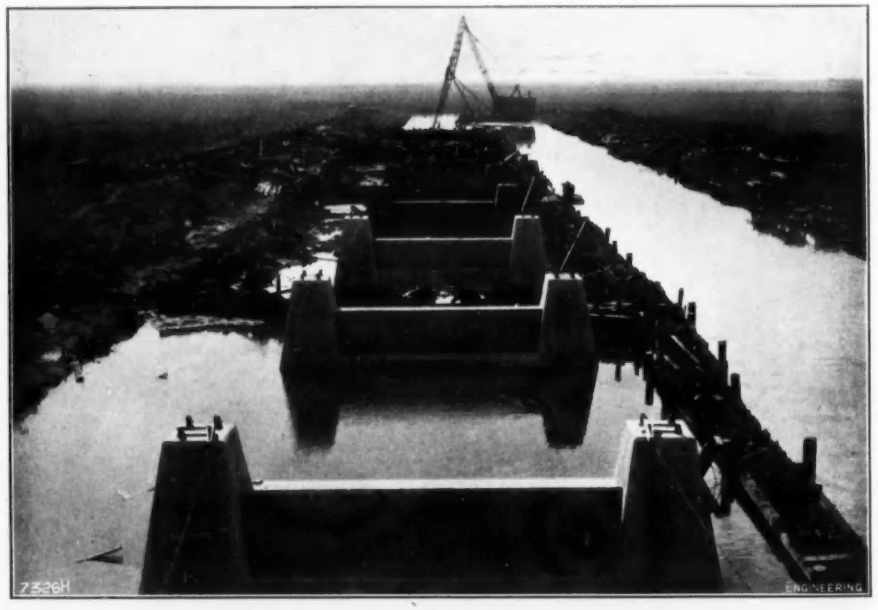


FIG. 14. PIERS FOR STEEL APPROACH SPANS.

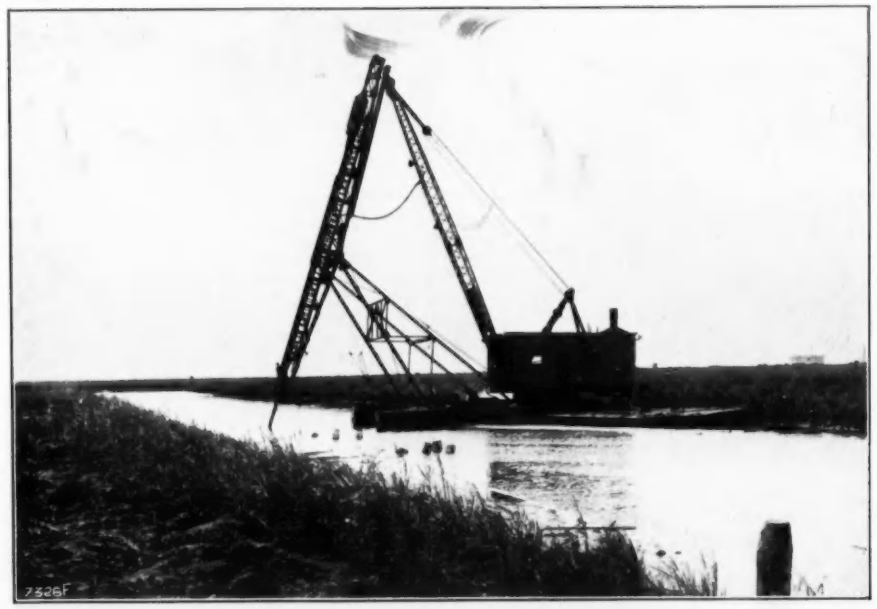


FIG. 15. FLOATING PILE DRIVER.

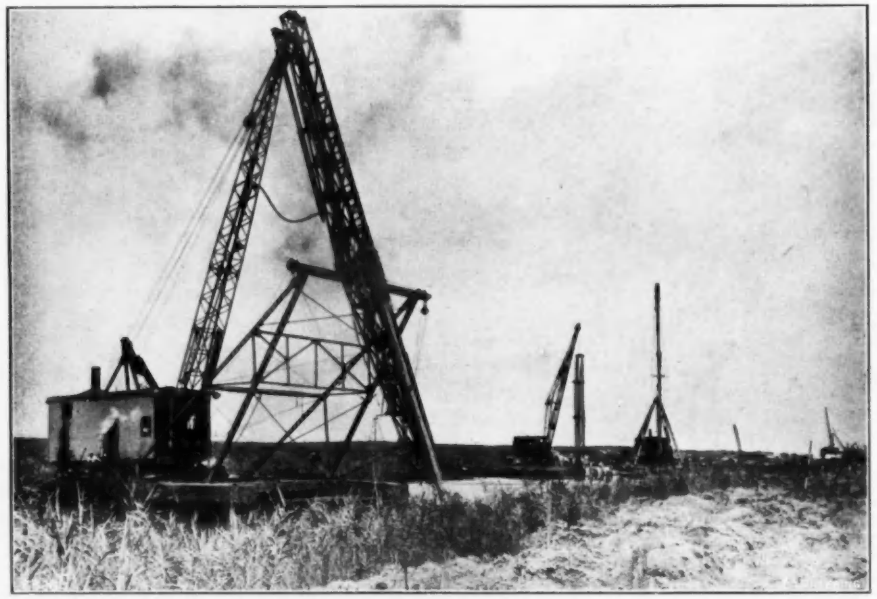


FIG. 16. PILE DRIVER IN OPERATION.

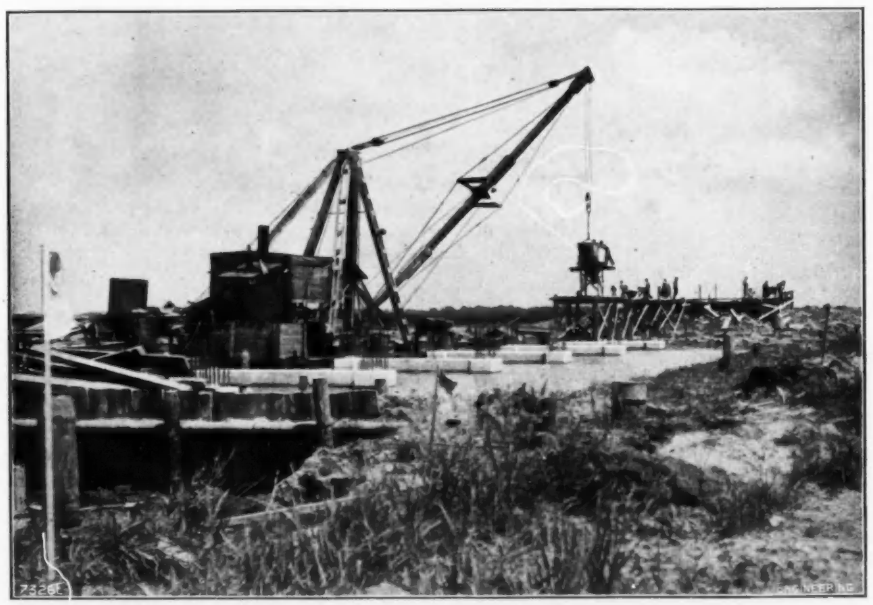


FIG. 17. PIERS FOR REINFORCED-CONCRETE SPANS.

(*To face page* 4.)

UNIV. OF MICH.

LAWRENCE HARGRAVE: MYTH AND FACT IN AERONAUTICAL HISTORY.*

By CECIL W. SALIER.

AUSTRALIANS, when they do not confuse Lawrence Hargrave with Edward Hammond Hargraves, the discoverer of gold at Ophir in 1851, have a general idea that Lawrence Hargrave had something to do with aeronautics; but the claims repeatedly made by Australian publicists on Lawrence Hargrave's behalf are based on inadequate knowledge both of aeronautical history and of Hargrave's own work, and are, I confidently submit, false.

Lawrence Hargrave did not "invent the aeroplane." He did not make the first heavier-than-air apparatus to fly; that distinction belongs to Stringfellow, and the flight took place in 1848, *i.e.*, two years before Hargrave was born. He did not first discover the principles of heavier-than-air flight; the credit for that is, by the general consent of our authorities, accorded to Sir George Cayley, in, particularly, his papers contributed to Nicholson's *Journal of Natural Philosophy*, in 1809-10.

The authority of the *Australian Encyclopædia* is quoted in support of two claims of a more specific character, but these, also, are not accordant with fact. (1) The late Professor Threlfall is reported to have said that "Sydney would one day be famous . . . for the fact that it had been the home of Lawrence Hargrave, the inventor of human flight." We have an unimpeachable statement from Threlfall, dated, May, 1895, and printed in his Anniversary Address to the Royal Society of New South Wales, which runs: "I cannot let this opportunity pass without expressing my strong conviction of the importance of the work which Mr. Hargrave has done towards solving the problem of artificial flight." Note the words of this statement, and compare them with the attributed ones. We have a second statement, dated 1923 (that is, eight years after Hargrave's death and twenty-five after Threlfall's departure from Australia), dealing in the main with Threlfall's personal memories and impressions of Hargrave. Of this, the sentence most pertinent to the claim runs: "He had an enormous knowledge of aerodynamics based on his experiments and on his natural aptitude for mathematical thought." I have been on the lookout, and have inquired in many quarters, and over something like a decade, for anything that could be evidential for the statement attributed to Threlfall, without success; and until there is produced valid and authoritative evidence in support of it, the Threlfall story must be disregarded.

(2) The other claim is that: "in 1900 Wilbur Wright asked permission to use his (*i.e.*, Hargrave's) patents, only to be told by Hargrave that he took out no patents and wished the Wrights every success in applying his discoveries," and "in 1903 the Wrights, by applying these principles (*i.e.*, those of Hargrave's box or cellular kites) to larger box-kites, solved the problem of human flight." Mr. Orville Wright has stated that there were only two letters from Hargrave, which were addressed to Wilbur Wright and dated October 11, 1903, and February 9, 1904; and that Hargrave did not supply any data about his work, the knowledge of which possessed by the Wrights was derived mainly from Chanute's *Progress in Flying Machines*, published in 1894. Copies of these two letters, as also of Wilbur Wright's reply to the first, are in my possession, and confirm Orville Wright's disclaimer of Hargravean influence on their work, a disclaimer that is confirmed to the full by a consideration of the nature and course of the aeronautical research of the Australian and American workers. The popular currency of this Hargrave-Wright story is largely due to the persistence of a "Wright obsession"—the excessive concentration of thought about aeronautical history on the success of the Wrights in 1903.

But if these claims on behalf of Hargrave are incorrect, what is the rightful place of Lawrence Hargrave in aeronautical history, and what justification is there for the Memorial now to be erected to him on Bald Hill,† overlooking Stanwell Park, New South Wales? Let me, in a brief space, summarise the facts.

After his early experiments on natural motion, Hargrave turned his attention to the problem of flight, in its two main sections, viz., the nature of the supporting surface, and the method of propulsion. His first flying machines were ornithopters, *i.e.*, driven by wing-flapping mechanism, and had no influence on the development of aviation. Hargrave, in 1889, invented a rotary engine. This type was later prominent among aeroplane engines; and its best known example, the Gnome, was very extensively used in the early days of aviation, when it was rightly esteemed for its combination of light weight and great power. The rotary engine had, however, certain disadvantages, and has now been superseded by the radial-cylinder type. The Gnome was patented by the brothers Laurent and Louis Seguin in 1908, and their invention was not influenced by knowledge of the work of Hargrave. Mons. Laurent Seguin, in a recent letter to myself, states that: "Les travaux qui nous ont conduits à l'invention de ce moteur ont été faits sans avoir aucune connaissance de ceux de Hargrave sur les moteurs. Bien entendu, nous connaissions ses études sur les cellules."* In the matter of the rotary engine, then, Hargrave must be regarded as an original and independent inventor, to whom should go the credit for first discovery, even though he himself did not profit monetarily by his invention. Hargrave, as is well known, was inveterately opposed to the idea and practice of patenting, which he maintained was calculated to retard progress, and to defer the solution of the problem of flight.

In what M. Seguin refers to as "les cellules," the matter stands differently. Under the impulsion of the knowledge of what had been achieved in aerodynamic research in England that came to him about 1891 through his entering into correspondence with the Aeronautical Society of Great Britain, Hargrave turned his attention to a study of the supporting surface for flying machines, to see whether his previous constructions might be improved upon and whether birds utilise the wind in soaring flight. He decided that kites offered the best form of apparatus through which to experiment; and he thereupon built many kites, which he called "kites of three dimensions." Some of these early forms are illustrated in the Royal Society's *Journal* for 1893; and all consist of surfaces of various shapes and sizes mounted at the ends of a main rib, the complete kite being "like two pieces of honeycomb put on the ends of a stick, the stick being parallel to the axis of the cells." This description by Hargrave gives us the origin of the term "cellular" applied to these kites.

He soon found that the cells could be reduced to two only, one at each end of the stick; and these cells then became like open boxes consisting of top, bottom and two ends, the front and back being open. Hence the alternative name of "box" kites. Further experiment demonstrated that, if the top and bottom surfaces were arched with the convex curvature upwards (or, as the term is, cambered), the pull of the kite on the string was doubled.

The next point was: Could these kites lift the weight of a man, as they would have to do in a practical flying machine? On the beach at Stanwell Park, on November 12, 1894, it was conclusively proved that they could; a set of four box-kites (though with plane, not curved, surfaces) lifted the inventor 16 ft. into the air, the wind then blowing at 21 miles an hour, and the total weight aloft being 208 lb. Hargrave triumphantly claimed that his experiments proved that "an extremely simple apparatus can be made, carried about, and flown by one man; and that a safe means of making an ascent with a flying machine, of trying the same without any risk of accident, and descending, is now at the service of any experimenter who wishes to use it."

The words quoted are the conclusion of Hargrave's communication to the Royal Society, made in June, 1895, when he reported his success and the details of the experiments that had led to it. But he had previously given an account, in similar terms, to the journal ENGINEERING, of London. That account was printed, with illustrations, in the issue for February 15, 1895—with important and historical consequences. It was seen by A. Lawrence Rotch, of the meteorological observatory attached to Harvard University, and situated at Blue Hill, Massachusetts. Now it happened that Rotch, and meteorologists generally at that time, were very interested in kites as a means of lifting their recording instruments into the upper atmosphere; and Rotch promptly made a Hargrave box-kite from the details in ENGINEERING. This he found very effective, and he thereafter became its champion. Almost simultaneously, the Hargrave kite, modified by Professor Marvin, was officially adopted by the Weather Bureau of the United States; and its use was inaugurated at seventeen observing stations in July, 1898. Thereafter, the meteorological use of box kites, based on the Hargrave original, spread rapidly. Of special interest in the present connection was their use at Trappes, near Paris, where they were installed by Mons. Teisserenc de Bort in 1898.

Both in France and the United States of America curved surfaces, the superior lifting power of which had already been determined by Hargrave, were substituted for the plane surfaces in the kites actually used in the Stanwell Park lift. For practical reasons, the systematic use of box kites in meteorology has, broadly, been discontinued, except at Lindenberg in Germany, where a kite lineally descended from Hargrave's model is in use to this day. It was at Lindenberg that the box-kite, used in a string of nine, attained its greatest height, 9,740 m., reached in 1919. Australians, also, should be interested to know that the late Professor David took a Hargrave kite to the Antarctic, but the blizzards there were too strong for it.

I have directed particular attention to the use of the box kite at Trappes; and its use there, as well as elsewhere, was widely publicised in French journals. Now it is a matter of common knowledge that the flight of Santos Dumont in October, 1906, the first officially recorded flight in history, and the later flights of Farman and Delagrange (in Voisin machines), were made in "box kite" aeroplanes; and it was, I believe, through the widely known use of the box kite in meteorology, especially in France, that the box kite entered into, and influenced, aeroplane construction. In explanation, let us go back a little.

The flights of the Wright brothers, on December 17, 1903, important though they were, were actually witnessed by only five other persons, and they were neither individuals of special importance nor interested in aeronautics. After these flights, the Wrights continued their work in privacy, almost secrecy; and their results were little known, even in their own country. Abroad, any news or rumour regarding their work was looked upon with scepticism, until about the flight of Wilbur Wright at Le Mans in September, 1908. In the years immediately succeeding 1903, the problem of human flight was inevitably regarded by aeronautical workers in Europe as still unsolved; but there was a continuance of effort towards that solution, descending, in France, from the lighter-than-air days of Montgolfier and Charles, through Nadar, Penaud and Ader to Santos Dumont and the other early successful flyers.

Although the success of the Wrights in powered flight was unknown in Europe, their work with gliders was more or less familiar; and in 1903, Archdeacon (better known, probably, through his aviation prize) attempted gliding with a Wright machine. It is not surprising that he was unsuccessful; he does not appear to have had previous gliding experience, and the manœuvring of the Wright machine in flight was an intricate business depending entirely on deliberate control operated by the pilot, who lay prone on the lower of the two planes. In the following year, 1904, Archdeacon tried a box-kite glider with better success; the apparatus not only possessed good lifting power, but the side pieces, or curtains, gave it inherent lateral stability. In these later trials, Archdeacon had the co-operation of Gabriel Voisin.

On October 23, 1906, Santos Dumont (who had also profited by the assistance of the Voisins) made his flight, checked and certified by the Aviation Committee of the Aero Club of France; and by July, 1908, Farman and Delagrange had made increasingly successful flights. Blériot, too, had experimented with an aeroplane of box-kite type, though it was in a monoplane that he flew the English Channel in 1909. Early English flyers also used box-kite machines. For a space, indeed, the box-kite aeroplane was the predominant type in Europe; and it was from the great aviation meeting at Rheims in August, 1909, that the tendency towards standardisation became operative.

From the evidence available, we are fully justified in drawing the following conclusions: (1) the problem of flight in a heavier-than-air, power-driven, man-carrying and man-controlled apparatus was solved in Europe in the years 1906-8 entirely independently of the Wrights in the United States; (2) that success came about, in part at least, through the aerodynamic qualities of the box kite, an apparatus invented and demonstrated by Lawrence Hargrave in Australia, thence communicated to the world, and extensively used in meteorology; (3) it is, perhaps, little exaggeration to say, with an American historian of aircraft (F. Alexander Magoun), that "had the Wrights never been born aviation would have been right where it is to-day."

Slight though might seem the occasion of Hargrave's lift at Stanwell Park on November 12, 1894; and little though its significance was, or hitherto has been, recognised, it was, as is shown in the facts I have summarised above, an event of high importance in the history of man's conquest of the air. It is, therefore, most fitting that Hargrave's association with Stanwell Park should be commemorated by a monument, the first to be erected to him in Australia, in that neighbourhood.

Near the top of Bald Hill three roads now meet, and a little to the north of their meeting point, on the new road running along the coast and into National Park, is the site reserved for the Hargrave Memorial. From the little park and resting spot that it is planned shall surround the memorial, visitors will be able to overlook the beach whence, nearly fifty years ago, Lawrence Hargrave made that brief kite ascent which was, indirectly, one of the great steps towards the final achievement of man's dream through the ages—Flight.

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* Reprinted from *The Australian Quarterly*, Sydney, N.S.W., March, 1940. Abridged.

† Work has not yet begun on Bald Hill.—C. W. S., February 20, 1940.

* "The researches which led us to the invention of this engine were conducted without any knowledge of those of Hargrave on engines. We were, however, acquainted with his study of cellular kites."

ELECTRIC RAILCAR FOR THE BEX AND VILLARS-CHESIERES RAILWAY.

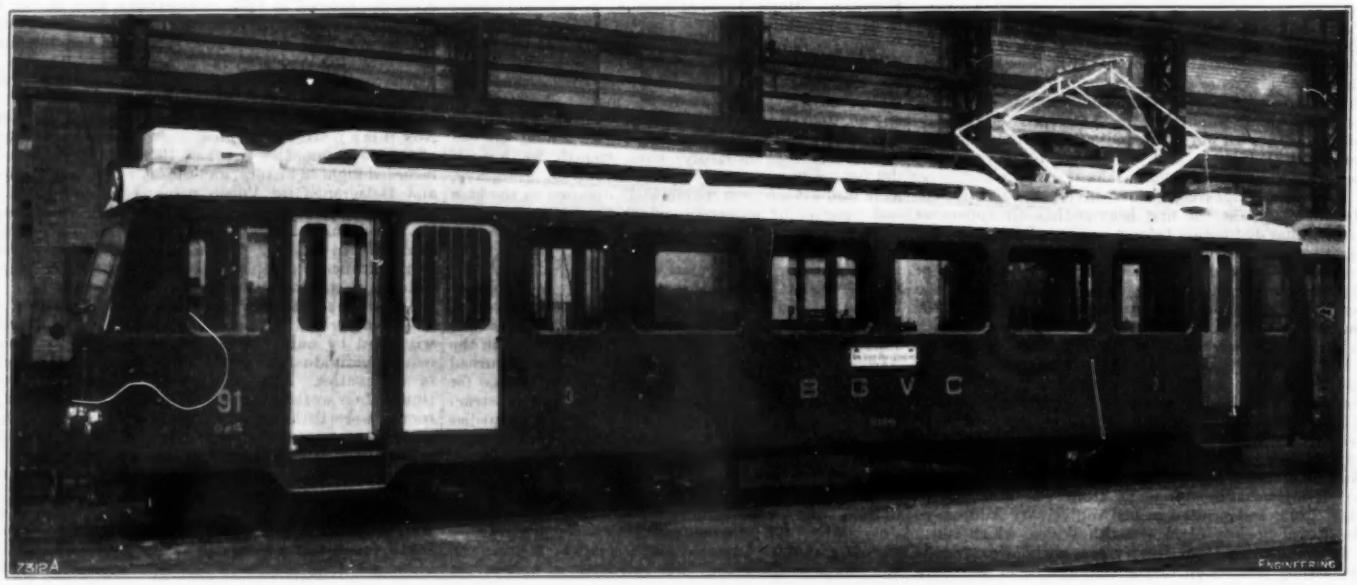


Fig. 1. General View of Car.

Fig. 2.

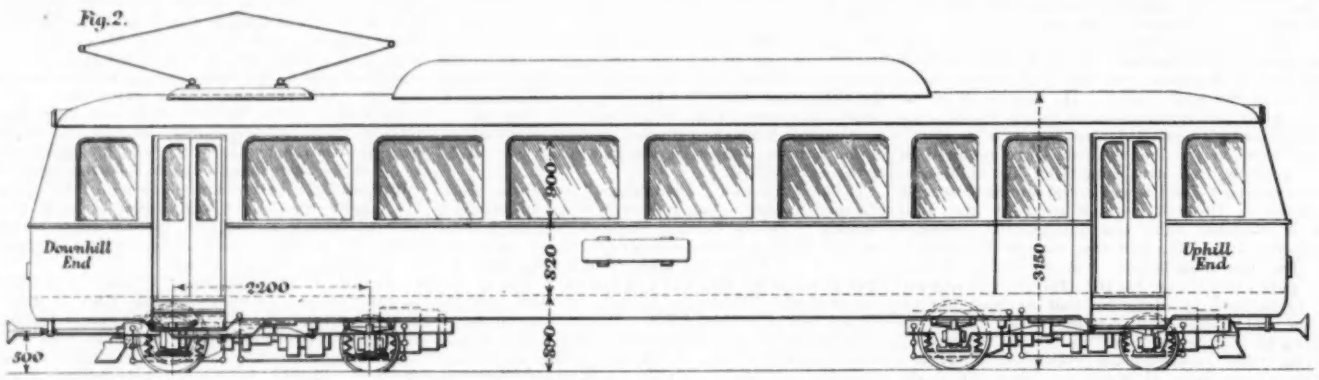
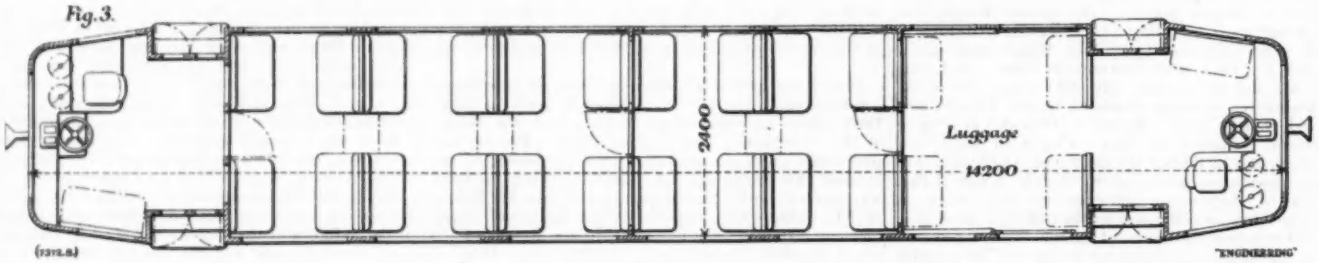


Fig. 3.



ELECTRIC RAILCAR FOR THE BEX AND VILLARS-CHESIERES RAILWAY.

The railway which runs from Bex on the Simplon main line to Villars-Chesieres via Gryon, in Switzerland, is 8·7 miles long, of which 3·1 miles is constructed for operation with a rack of the Abt type. It is of one-metre gauge and the maximum gradient is 1 in 5 on the rack section and 1 in 16·5 on the adhesion section. Owing to the increased traffic on this railway, which at Villars connects with a rack railway to Breaye, at number of modern cars have recently been put into service and the journey time has thus been reduced from 78 minutes to 45 minutes, while Bretaye can be reached in a little over an hour from Bex.

The design and construction of the new cars, as well as of the mechanical transmission, was undertaken by the Swiss Locomotive and Machine Works, Winterthur, while Messrs. Oerlikon supplied the electrical equipment. The general lay-out of the car will be clear from Figs. 2 and 3, while its appearance is shown in Fig. 1. The railcar is 48 ft. 2 in. in length over the buffers and 7 ft. 10¼ in. wide, while the height above the rails is 10 ft. 4¼ in. The tare weight is 19 tons and the fully-laden weight 25 tons. The frame is of light steel construction and, generally speaking, the connection of the various parts has been effected by welding. Light-metal alloys were used for portions which are not subjected to any great stress, such as the roof and doors, as well as for some of the internal fittings, such as the luggage racks. The floors in the passengers' compartments are covered with linoleum, while the walls are covered with imitation leather up to the bottom of the window frames. The colour of this leather is the same as that used for upholstering the seats. The upper parts of the walls are panelled with veneered plywood in light shades. The seats have been carefully designed to ensure the comfort of the passengers on the steepest gradients and the windows are wide enough to provide a good view in every direction.

Access to the interior of the car, the appearance of which is illustrated in Fig. 8, on Plate II, is obtained through a door at each end, which also lead to the driver's cab. Each driver's cab, a view of which is given in Fig. 9, on Plate II, is equipped with the necessary controlling apparatus, including a dead-man's pedal. Except when the traffic is particularly heavy, the driver also acts as guard and controls the doors at his end of the car by a lever, the other doors being locked. Next to the driver's cab at the up-hill end is a luggage compartment. The passenger accommodation is divided into two, for smokers and non-smokers, respectively, the total seating capacity being forty. In addition, there are 12 folding seats in the luggage compartment and also room for 12 people to stand.

As will be clear from Fig. 2, the frame is carried on two bogies, which are of practically identical design. The car is supported on the bogies on four laminated springs, rubber pads being used in addition to absorb the shocks. Each bogie, one of which is illustrated in Fig. 6, on Plate II, is provided with a driving and trailing axle, the former leading when the car is travelling up hill. These driving axles are both driven by a 125-h.p. 650-volt direct-current motor, through the transmission gear shown diagrammatically in Fig. 5, opposite. As will be seen from this diagram, the power developed by the motor *a* is transmitted to the cardan shaft *b* through the reduction gear *c*. The cardan shaft is fitted with two universal joints and the gear is designed so that torque is transmitted to the driving axle *d* and the rack pinion *e*. As will be recalled, in the Abt system the rack pinion has two rims in each of which teeth are cut, and these engage with corresponding teeth on the rack. A friction coupling, which slips when the torque becomes excessive, is interposed between the motor and the first reduction gear. From the cardan shaft the drive is transmitted through a bevel gear to the two gear wheels *g* and *h*. The former of these transmits the torque to the driving axle *d*. The gear wheel *h* transmits the drive to the rack

ELECTRIC RAILCAR FOR THE BEX AND VILLARS-CHESIERES RAILWAY.

(*For Description, see Page* 6.)

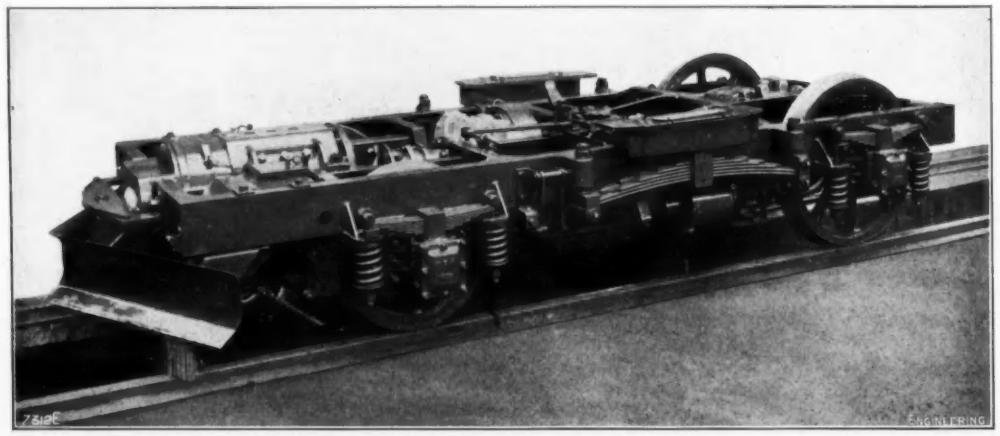


FIG. 6. BOGIE OF RAILCAR.

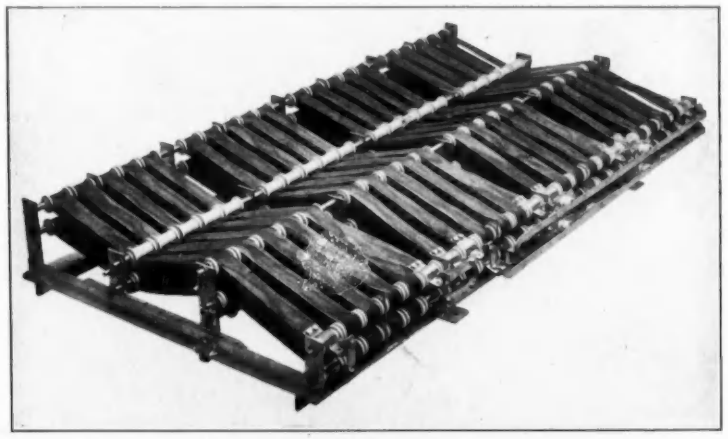


FIG. 7. ELECTRIC-BRAKE RESISTANCE.

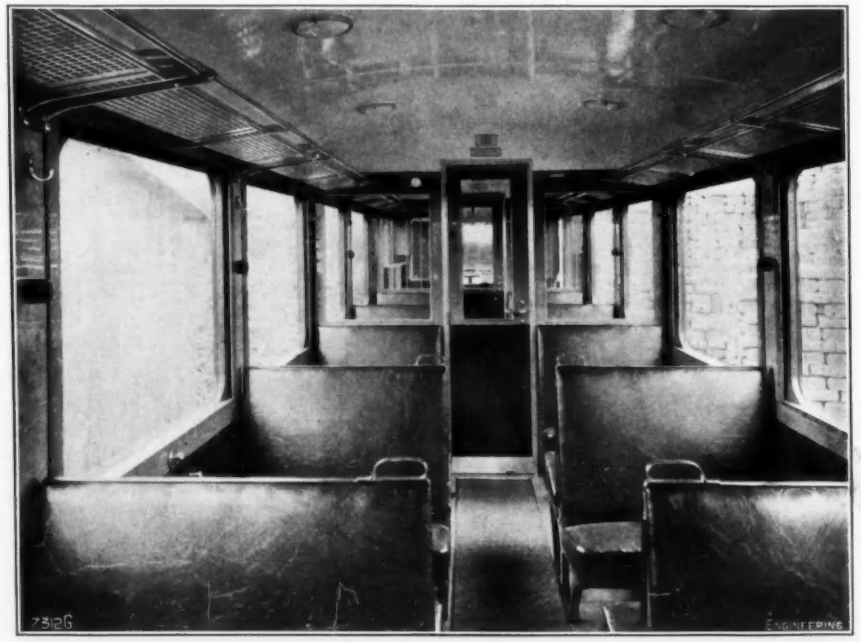


FIG. 8. INTERIOR OF CAR.

FIG. 9. INTERIOR OF DRIVER'S COMPARTMENT.

(*To face page* 6.)

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RAILCAR FOR BEX & VILLARS-CHESIERES RAILWAY.

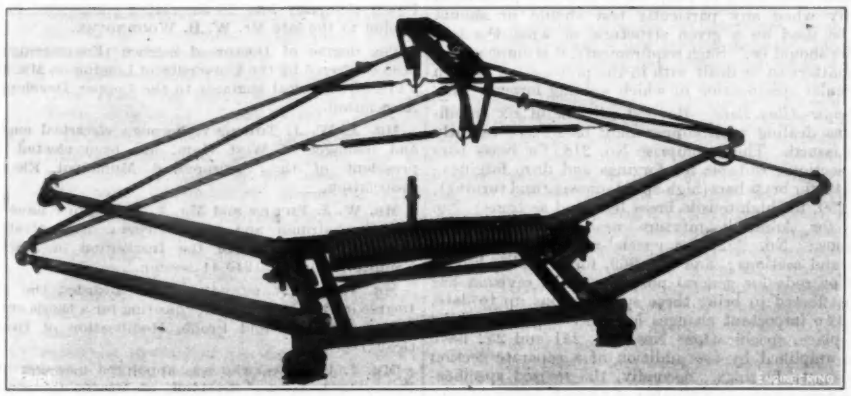
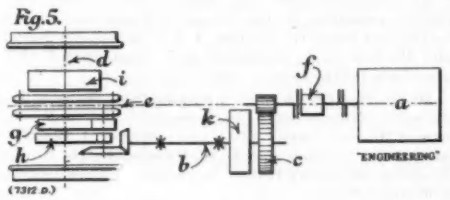


FIG. 4. PANTOGRAPH CURRENT COLLECTOR.



pinion *e*. Springs, which are incorporated in the gear wheel *c*, and in the rack pinion *e*, ensure both a smooth transmission of the torque and quiet engagement between the pinion and the rack. The rack pinion is fitted with a bush, which is loose on the axle *d*, but is rigidly connected to the gear wheel *g*. The car is prevented from slipping back on the rack section by a brake, the drum of which is shown at *i*. This brake is full on during the upward journey on the rack portion of the line.

In view of the fact that the speed on the rack section has been increased to 9·83 m.p.h. on the upward journey, compared with 5·6 m.p.h with the original cars, particular attention was paid to the design of the safety devices and especially of the brakes. Five brakes are provided in all: A rheostatic brake by means of which the speed downhill is controlled on both the rack and adhesion sections; a manual brake which is operated from the driver's cab and acts on a drum on the secondary shaft of the first reduction gear, as shown at *k* in Fig. 5; and a second manual brake which operates a block forming part of the manual brake of the rack pinion. In addition, there is an automatic brake which acts on the drum *k*. This brake is actuated by a helical spring, which is normally in tension and is released automatically by an electromagnet when the speed downhill on the rack section exceeds 11·2 m.p.h. It also acts when the dead-man's pedal in the driver's cab is released or when the braking circuit is interrupted. Finally, there is a direct-acting air brake, the blocks of which are applied simultaneously on all eight wheels. Both bogies are fitted with the brakes described and they can be operated from either end of the car. One of the braking resistances is illustrated in Fig. 7, on Plate II.

Direct-current at 650 volts is obtained from an overhead line through a pantograph collector, a view of which is given in Fig. 4, above, and is supplied to the two direct-current series-wound motors, which are permanently connected in series. The output of each motor at the normal voltage is 125 h.p. at a one-hour rating when running at 1,500 r.p.m. Speed regulation up to the maximum of 18·7 m.p.h. is obtained by weakening the fields. The controller is of the cam-disc type, which operates contactor elements. There is also a reversing switch and braking notches.

FLUID-FILLING MEDIA FOR ELECTRICAL APPARATUS: ERRATA.—We regret that in the article on "Fluid-Filling Media for Electrical Apparatus," which appeared on page 586 of our issue of June 14, Mr. D. V. Onslow was stated to be a member of the staff of the British Electrical and Allied Manufacturers Association. This should have been the British Electrical and Allied Industries Research Association. This body was responsible for the work described by Mr. Onslow and commented on in our article. Mr. Onslow's initials were also incorrectly given as D. M. instead of D. V.

TEMPERATURE EFFECTS IN GRASS DRYING.*

By A. W. SCOTT, Ph.D., B.Sc.

THE subject of grass drying has received much attention in recent years and a fairly extensive grass-drying industry has been developed. The aim of the process is the conservation of young grass as a fodder concentrate, and to effect this the freshly-cut grass is dried until the moisture content is less than 10 per cent. The drying medium is heated air or, more usually, air mixed with the products of combustion from a coke or coal furnace. The temperature at which the air or gases should be supplied to the drier is a question of primary importance. The drying capacity of a given plant increases markedly as this temperature is raised, and hence the capital costs per ton of product are decreased. A limiting temperature condition is reached when the product becomes scorched during drying.

The present paper deals with investigations on the effect of drying temperature on (*a*) the scorching of the grass, and (*b*) the rate of evaporation. The experiments were confined to "mat" drying conditions, *i.e.*, the drying air was passed up through a stationary mat of grass, in contrast with pneumatic drying in which the grass is conveyed through the drier by the drying air stream. Throughout the series of tests the depth of grass layer was about 3 in., since temperature effects are obscured with thicker layers. Lawn grass was used, and, before starting a test, the grass was thoroughly soaked and the excess moisture thrown off by whirling. The initial gross weight of basket and suspension fittings plus wet grass was kept constant at 5·29 lb. The mean gas speed in the duct was 5 ft. per second.

Series (i). *Scorching Tests.*—The object of this series was the examination of the limiting temperature conditions for mat drying. The method of testing may be explained by reference to the tests at 450 deg. F. When the gas temperature had attained a steady value of 450 deg. F., the first sample was placed in the drying duct and exposed to the drying gas stream for 1½ minutes. The fan was then shut off and the basket containing the sample was removed and weighed. The sample was removed from the basket for subsequent comparison, without disturbing the arrangement of the grass layers. This was repeated with samples of the same initial weight but with the time of exposure increased to 3, 5 and 7 minutes, respectively. Separate series were carried out for temperatures of 400 deg., 350 deg., and 300 deg. F., the times of exposure being increased at the lower temperatures. Each sample was examined and the approximate points noted at which fading of the green colour and scorching had first developed.

On the evidence of these tests, the best gas or air supply temperature for mat driers is about 300 deg. F., and should certainly not exceed 350 deg. F. At higher temperatures very definite local scorching quickly occurs. Thus, at 450 deg. F., after 1½ minutes drying, the major portion of the grass mass was quite damp and fresh, but in some places there were what can best be described as chimneys or channels of scorched grass. This is due to the fact that, no matter how carefully the layers of grass are distributed, some parts of the grass mat will offer less resistance than others to the drying stream. The gas-flow rate through these weaker portions is greater than through the mass, and this effect quickly becomes cumulative since the resistance decreases as the grass dries. At low temperatures this results in the creation of blow holes in the mat, through which the gases escape without doing useful work. At temperatures of the order of 450 deg. F., however, there is the additional disadvantage that drying is so rapid in the weaker zones of the layer that charring quickly occurs and uniformity of drying becomes impossible.

Series (ii). *Effect of Temperature on Rate of Drying.*—In this series, tests were carried out at temperatures ranging from 70 deg. to 350 deg. F., the initial grass weight and gas-flow rate being kept constant throughout. In carrying out these tests two methods of weight measurement were used. In the first method the times were noted for decrements of 0·1 lb. in the balance reading, the gas flow being continuous throughout the test. To obtain the true basket weight, the balance readings were then corrected for the up-thrust of the gas stream. In the second method, the gas stream was shut off at regular time intervals and the true basket weight measured directly. Good agreement was found between the curves obtained by the two methods, but the results by the second proved slightly more consistent. The tare weight of the basket and suspension was 4·37 lb., and the average weight of the basket, suspension and dried grass was 4·47 lb. The lower temperature limit was 55 deg. F., which was the mean dew-point temperature of the supply gases in the tests. No evaporation is possible below this temperature. Some points deviated from the mean curves, but this is almost inevitable. In addition to the variation in drying rate caused by the channelling effect previously mentioned, it was impossible to obtain two grass samples identical in composition. Hence, since the leafy portion of grass dries more rapidly than the stemmy parts, some variation in drying rates must be expected. This variation in structure, together with the variation in moisture content of freshly cut grass, have provided a serious problem in commercial drying.

Irregularities may develop in converting the results from gross weight to moisture content. Thus, at 80 per cent. moisture, an error in weight of 1 per cent. involves an error in the moisture content of about 2 per cent.; at 40 per cent. moisture, the same error in weight produces an error of about 16 per cent. in the moisture content. For a given drying temperature, the rate of evaporation is greatly influenced by the moisture content of the grass, being much greater with grass of high moisture content. This point does not appear to have been appreciated in the past. Moisture contents of 70 per cent. to 88 per cent. cover the range of values obtained for freshly cut grass, and the comparative ease with which the initial 10 per cent. to 15 per cent. of moisture can be driven off is very striking. A reduction in moisture content from 88 per cent. to 70 per cent. would remove two-thirds of th water in the grass, and this reduction could be effecte in a reasonable time by employing atmospheric or slightly heated air. It is, therefore, suggested that such a scheme of preliminary drying by "forced wilting" before passing the grass to commercial driers would greatly increase the output and economy of these dryers. In the experiments with atmospheric air at 70 deg. F., this idea was further extended. The grass was dried to about 25 per cent. moisture in the plant and then left overnight in the heated atmosphere of the College boiler house. The final product was perfectly dried grass which had retained the full colour of fresh grass. The evaporative capacity of a given drier decreases appreciably as the moisture content of the wet grass is reduced; thus, the specification of a drier should state the output for various moisture contents.

Conclusions.—The main findings may be summarised as follows:—(1) The efficiency of a carefully designed low-temperature mat drier need not be appreciably less than that of a high-temperature pneumatic drier. (2) For a mat drier, the limiting temperature at which uniform drying can be obtained without severe local scorching is in the region 300 deg. to 350 deg. F. (3) Conversely, with higher temperatures than these, the rate of evaporation and, therefore, the capacity of a drier increases rapidly. It is probable, however, that even with pneumatic drying, the difficulty of obtaining uniform drying will become more marked as the drying temperature is increased. (4) The rate of evaporation with fresh wet grass is much greater than with grass of lower moisture content. Advantage could be taken of this fact by employing atmospheric air to evaporate the initial moisture in very wet grass.

* Report on research carried out, for the Agricultural Research Council, at the Royal Technical College, Glasgow, and recorded in the *Journal* of the College, vol. 4, part 4, page 725 (1940). Abridged.

CANADIAN COLLIERY INDUSTRY.—According to figures issued by the Dominion Bureau of Statistics, Ottawa, the production of coal in Canada totalled 15,519,464 tons in 1939, constituting an increase of 8·6 per cent. over the 1938 output.

STAINLESS STEELS CONTAINING SILVER AND MOLYBDENUM.

SOME interesting information regarding the properties of stainless steels of the 18/8 chromium-nickel type, to which additions of silver and molybdenum are made, is contained in recent issues of *The Nickel Bulletin*, a publication issued by Messrs. The Mond Nickel Company, Limited, Thames House, Millbank, London, S.W.1. Research carried out at the Massachusetts Institute of Technology indicates that the silver, which is added in proportions of the order of 0·1 per cent. to 0·3 per cent., counteracts the tendency of the material to suffer pitting corrosion as the result of attack by ferric and other chlorides, and sea water. It is pointed out that chlorides of iron, nickel and chromium are soluble, whereas the silver, which is homogeneously dispersed throughout the mass of the material, forms an insoluble chloride and this fact, it is claimed, greatly enhances the resistance of the steel to pitting corrosion. Further, the silver-bearing 18/8 steel is more easily machinable, and undergoes a lower degree of work-hardening than that containing no silver. In support of this, it is stated that, under conditions which would permit of turning ordinary 18/8 steel with a cutting speed of 70 ft. per minute, a silver-containing steel will allow a cutting speed of approximately 100 ft. per minute to be employed without tool failure. It is, moreover, claimed that the silver-bearing steel has a higher thermal conductivity than the ordinary alloy, and that the capacity for taking a high polish is further increased. Owing to the tendency of silver to volatilise at the melting temperatures employed in the manufacture of these high-alloy steels, however, the silver must be introduced into the material in the form of a master alloy of nickel and silver.

From the few results published, the tensile strength and ductility of castings of the new steels appear to be very similar to those of the straight nickel-chromium alloy steel, but the silver-containing steel is said to possess improved forging qualities. According to a paper read before the Electrochemical Society by Mr. G. F. Landgraf, improvement in the resistance of stainless steel to pitting corrosion in sea water and other chloride solutions has also been effected by the addition of molybdenum, but the use of this type of steel is limited by difficulties in fabrication. The proportion of molybdenum added is not quoted in the *Bulletin*, although it is stated, in connection with work conducted at the Massachusetts Institute of Technology, that the tensile properties of two castings of 18/8 steels containing, respectively, 2·93 per cent. of molybdenum and no silver, and 3·02 per cent. of molybdenum and 0·28 per cent. of silver, have been determined. From these two results it would seem that the molybdenum increases the ultimate strength value and reduces the percentage elongation of the alloy.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

War-Time Street Lighting.—With a view to allowing greater flexibility in the siting of street-lighting fittings, the specification dealing with war-time street lighting (B.S./A.R.P. No. 37) has been revised in respect of clause 4, which relates to mounting height and spacing. No change has been made in regard to fittings to be used for spacings of not less than 100 ft., but additional information is now given on how to install fittings in situations in which the pole spacings are between 50 ft. and 100 ft. This revision has been set out on a sheet, designated C.F. (A.R.P.) 5597, copies of which may be obtained from the Institution, on request, enclosing a stamped addressed envelope.

Testing of Fusion Welds and Welded Joints.—A revision of specification No. 709, which deals with methods of testing fusion welds, welded joints and weld metal, applicable to the electric-arc welding of steel, has recently been published. When first issued in November, 1936, the publication was confined to the standardisation of the bend test as applied to welds and welded joints. A number of other tests, however, are now widely used for the testing of welds, and the present revision has been undertaken in order to include standards for forms of test other than bending and to co-ordinate and simplify the various tests which are already in existence. The tests dealt with include a tensile test on butt welds, ductility tests, and notched-bar impact tests. The advantages resulting from the adoption, throughout the industry, of similar test pieces and of identical methods of testing are obvious, as they enable test data to be readily compared and correlated. In the present specification a general indication is given of the use to which each of the different tests may be put, but it does not purport to specify when any particular test should or should not be used on a given structure, or what the test results should be. Such requirements, it is emphasised, are matters to be dealt with in the preparation of each particular specification in which welding forms a part.

Copper-Alloy Bars.—Revised editions of six specifications dealing with copper-alloy bars have recently been issued. These comprise No. 218, for brass bars and sections, suitable for forgings and drop forgings; No. 249, for brass bars (high-speed screwing and turning); No. 250, for high-tensile brass bars and sections; No. 251, for Admiralty-mixture naval-brass bars and sections; No. 252, for special-mixture naval-brass bars and sections; and No. 369, for phosphor-bronze bars or rods for general purposes. The revision has been effected to bring these specifications up to date, and two important changes have been made. In the first place, specifications Nos. 218, 251 and 252 have been amplified by the addition of a separate section relating to forgings. Secondly, the revised specifications now supersede a number of aircraft specifications. [Price 2*s.* 3*d.* each, postage included, or 12*s.* 6*d.* for the set of six publications.]

Screw Threads of Whitworth Form.—The work on the revision of specifications Nos. 84 and 92 for B.S. Whitworth and B.S. fine screw threads, which has been in hand for some time, has now been completed by the issue of a new specification bearing the title "Screw Threads of Whitworth Form." The new publication, which bears the number 84-1940, is in the form of a cloth-bound book of 65 pages and supersedes specifications Nos. 84-1918 and 92-1919. It is considerably more comprehensive than the previous specifications and embraces, in one publication, tables of basic sizes and tolerances not only for B.S.W. and B.S.F. screw threads, but also for B.S. pipe (parallel) threads in cases in which, on account of their relatively fine pitches, they are employed for general-engineering purposes as distinct from ordinary pipe joints. Further, the specification is rendered still more comprehensive by providing, for the first time, series of recommended tolerances for all other Whitworth-form threads having any reasonable combination of diameter, pitch, and length of engagement. Tables of limits and tolerances are given for the B.S.W., B.S.F., and B.S.P. (parallel) series in three grades of accuracy. These tolerances are on a basis different from those which appeared in the earlier specifications. They have been arrived at from a close study of the accuracy of modern screwing tools and methods, combined with due consideration of the general quality of screw threads now in use in the various spheres of engineering production. Although a new basis has been adopted for the effective-diameter tolerances, their actual values are closely comparable with the corresponding tolerances given in the previous specification Nos. 84 and 92. This applies also to the new tolerances on the major and minor diameters of bolts. On the other hand, a substantial increase has now been made in the tolerances for the minor diameters of nuts, as their former values had been found to be inadequate for general production purposes. The larger tolerances permit the use of tapping drills of ample size for facilitating tapping, and minimising the risk of tap breakage, especially on the smaller sizes of threads. Particular attention may be drawn to the general formula now used as a basis for the effective diameter tolerances. Whereas these tolerances had formerly been based solely on the pitch of the thread, the formula now adopted takes account of the diameter of the thread and its length of engagement, as well as its pitch. The appendices to the specification relate to nomenclature and definitions, and include notes in regard to workshop and inspection gauges. In a special foreword, it is emphasised that, while the introduction of the new specification in place of the previous editions—Nos. 84-1918 and 92-1919 and other screw-thread specifications—is generally to be desired, caution should be exercised in changing over to the new standard if, during the present national emergency, such a change might in any way hamper and delay production. [Price 5*s.* net, or 5*s.* 4*d.* postage included.]

MACHINERY AND PLANT (CONTROL) ORDER, 1940.—In pursuance of the powers conferred upon it by paragraph (2) of Article 3 of the Machinery and Plant (Control) Order, 1940, the Board of Trade can request any person carrying on, or employed in connection with, the business of manufacturing any machinery or plant described in the Schedule of that Order to produce on demand, to any of H.M. Inspectors of Factories, any certificate held by him forming part of a licence by virtue of which any person is authorised to acquire any such machinery or plant.

PERSONAL.

COLONEL H. C. FRASER, D.S.O., M.I.E.E., has been appointed general manager of the Yorkshire Electric Power Company and its associated companies, in succession to the late Mr. W. B. WOODHOUSE.

The degree of Doctor of Science (Engineering) has been conferred by the University of London on MR. H. G. TAYLOR, electrical engineer to the Copper Development Association.

MR. J. W. J. TOWNLEY, borough electrical engineer and manager of West Ham, has been elected vice-president of the Incorporated Municipal Electrical Association.

MR. W. J. PICKEN and MR. T. E. GOLDUP have been elected chairman and vice-chairman, respectively, of the Wireless Section of the Institution of Electrical Engineers, for the 1940-41 session.

MR. HARRY WALKER has been awarded the Ph.D. Degree in the Faculty of Engineering for a thesis entitled "The Deflection and Profile Modification of Involute Gear Teeth."

MR. J. U. VASS, who was appointed manager of the Fraserburgh Works, Scotland, of Messrs. Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6, in 1921, has now been appointed a director.

MR. GRIFFITH BREWER, Hon.F.R.Ae.S., has been elected president of the Royal Aeronautical Society for the year 1940-41. LT.-COL. J. T. C. MOORE-BRABAZON and PROFESSOR L. BAIRSTOW have been elected vice-presidents for the same period.

MR. D. B. BUTLER, who is retiring from business, has disposed of his practice, both personal and under the title of MESSRS. HENRY FAIJA AND COMPANY, 1, Buckingham Gate, London, S.W.1, to MESSRS. R. H. HARRY STANGER, Broadway House, 24, 26 and 28, Tothill-street, London, S.W.1.

MESSRS. BRITISH JEFFREY-DIAMOND, LIMITED, Stennard Works, Wakefield, have appointed MR. A. YORKE SAVILLE to be managing director of the Company, in succession to the late MR. J. F. I. THOMAS, O.B.E. Mr. Saville was formerly chief engineer and was appointed assistant managing director in May last.

MR. R. BORLASE MATTHEWS, M.I.E.E., informs us that he has resigned from the chairmanship of Associated Smaller Manufacturers.

BOOKS RECEIVED.

United States Bureau of Mines. Supplement to List of Publications, Bureau of Mines. July 1, 1938, *to June* 30, 1939. *With Subject and Author Index.* Washington: Superintendent of Documents.

United States Bureau of Mines. Technical Paper No. 607. *Tabulated Analyses of Texas Crude Oils.* By A. J. KRAEMER and GUSTAV WADE. Washington: Superintendent of Documents. [Price 15 cents.]

United States Bureau of Mines. Miners' Circular No. 40. *Some Information on Timbering Bituminous-Coal Mines.* By J. J. FORBES and C. W. OWINGS. [Price 10 cents.] Miners' Circular No. 41. *Accidents from Falls of Rock or Ore in Metal Mines.* By E. H. DENNY. [Price 5 cents.] Washington: Superintendent of Documents.

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich. London: The Astronomer Royal, The Royal Observatory, Greenwich, S.E.10.

United States National Bureau of Standards. Handbook H 33. *Safety Rules for the Installation and Maintenance of Electric Utilization Equipment. Comprising Part* 3 *and the Grounding Rules of the Fifth Edition, National Electrical Safety Code.* Washington: Superintendent of Documents. [Price 15 cents.]

The University of Minnesota. Engineering Experiment Station. Bulletin No. 17. *Methods of Moisture Control and Their Application to Building Construction.* By PROFESSOR F. B. ROWLEY, PROFESSOR A. B. ALGREN, and C. E. LUND. Minneapolis, Minn., U.S.A.: The Director, Engineering Experiment Station. The University of Minnesota.

Industrial Surveys and Reports. By PROFESSOR WALTER RAUTENSTRAUCH. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 15*s.* net.]

Legal Aspects of Engineering. By W. C. SADLER. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 24*s.* net.]

Acoustics. A Handbook for Architects and Engineers. By P. L. MARKS. London: The Technical Press, Ltd. [Price 7*s.* 6*d.* net.]

Properties of Ordinary Water-Substances in All Its Phases: Water-Vapour, Water and All the Ices. Compiled by N. E. DORSEY. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 90*s.* net.]

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Fluorescent-Tube Lighting Equipment for Grand Hall, Cape Town City Hall. Electricity Department, Cape Town; August 14. (T. 20,647/40.)

Isolating Links, 500, outdoor-type, 200-ampere, 2,000-volt, mounted on base plates and fitted with galvanised-iron hoods at the bases of the insulators. City Council, Johannesburg; August 14. (T. 20,650/40.)

Tools, comprising shovels, picks, ballast forks and handles. South African Railways and Harbours, Johannesburg; September 2. (T. 20,651/40.)

Low-Tension Switches, one bank of nine, metal-clad, pedestal-mounted, draw-out, triple-pole, oil-break type, suitable for operation on a 380/220-volt, three-phase, four-wire, 50-cycle system; each switch to have a rupturing capacity of not less than 15,000 kVA at 380 volts. Union Tender and Supplies Board, Pretoria; August 1. (T. 20,655/40.)

Electric Trolley-Omnibus Chassis, ten, with double-deck bodies of the all-metal type, capable of seating 60 passengers. City Council, Pretoria; July 30. (T. 20,658/40.)

Underground Cables. With reference to the call for tenders for 88-kV underground cables for Orlando power station, noted on page 522, *ante*, we now learn that the Electricity Department, City Hall, Johannesburg, has extended the closing date from June 27 until July 25. (T. 19,463/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—It was announced on the Welsh steam-coal market during the past week that Mr. R. Whitfield Parker, who has held the position of Coal Export Officer, Mines Department, at Cardiff, Barry and Newport since the beginning of hostilities, was to return to London immediately to resume duties in connection with miners' welfare. Mr. Parker has been succeeded at Cardiff by Mr. F. W. Cresswell. As a result of the stopping of the trade with France, coals were readily available for early shipment, although sellers were not pressing and the general tone was firmly maintained. Operators interested in certain trades, notably South America and Portugal, were doing a moderately good business. Demand in these markets has been briskly upheld and it was confidently expected that, as a result of the freeing of supplies, the district would be able to regain a great deal of the ground that has been lost in these directions in recent years. For the present, outputs at the mines were being actively maintained and the steps which have been recently taken to improve the output of the district are not being relaxed. Mr. D. R. Grenfell, the Minister of Mines, speaking in the coalfield recently, referred to the possibility of re-opening some of the pits which had long been idle.

The Iron and Steel Trade.—Busy conditions again ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. Most works remained well stemmed with orders and the demand was still active.

ARTUS MILLING-CUTTER SPACERS.—Messrs. International Auto Aero Specialities, Limited, 44, Packington-road, London, W.3, inform us that they have taken over from Mr. A. Penkuhn the manufacturing and selling rights for the well-known Artus milling-cutter spacers. On page 170, *ante*, we referred to Mr. Penkuhn's acquisition of the manufacturing and sales rights of the spacers, and, on page 517 of ENGINEERING, vol. 146 (1938), we gave a description of them. It will be recalled that the spacers are made of synthetic resin and are claimed to be non-hygroscopic and impervious to oil. They are supplied in thicknesses ranging from 0·001 in. upwards, each of which has a distinctive colour.

OLD BELL AND CLOCK AT DERBY RAILWAY WORKS.—Despite successive modernisations, some of the original engine houses and other buildings, at the London Midland and Scottish Railway Works, Derby, which recently celebrated its centenary, are still in use for various purposes. The most historic relic connected with the works, however, is the bell of the turret clock in the Locomotive Offices; it bears the date 1717 and is still in use. It is believed that this bell was taken from the old St. Pancras Chapel, London, when this building was demolished about 1865, in connection with the building of St. Pancras Station. The clock itself is 100 years old, having been made in 1840 by Whitehurst of Derby, and every care is being taken by the railway authorities to keep it in good working condition for ultimate preservation as an historic relic.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The foresight which South Yorkshire industrialists displayed during the days of depression in carrying out works extensions and the modernisation of their plant is now proving its value. As a direct result, the large steel and engineering works are now able to meet the record demands made upon them. No material change has developed in the raw and semi-finished steel-producing sections, but every effort is being made to enlarge outputs still further. Activity in the heavy machinery and engineering branches continues. Firms specialising in the production of equipment and tools for the shipbuilding industry are exceptionally busy. Increased tonnages of forgings, castings, machinery, and deck furnishings are leaving this area for the shipyards. Makers of railway rolling stock are accounting for an increased output as compared with six months ago. Overseas requirements show little change, though Egypt, South Africa, and India are stated to be better customers; inland sales are also increasing. Among the lines in demand are axles, wheels, springs, tyres, and buffers. Business in concrete and cement-mixing machines continues brisk, and the demand for agricultural machinery and parts has been well maintained; harvesting machinery and tools are being ordered in large quantities.

South Yorkshire Coal Trade.—For the time of year, the demand for household fuel reaches a high level, customers continuing to buy heavily for winter-stocking purposes. The inland demand for industrial coal is strong. Increased outputs at many pits are quickly taken up, and stocks at colliery sidings are low. The coke market continues to be active, both foundry and furnace grades being in strong request.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No change can be reported in the state of the Scottish steel trade and all plant is working at full capacity. The need for speeding up is fully recognised by all connected with the industry and the output of steel material of all kinds is increasing. Although this is the usual holiday month in the West of Scotland, there is not likely to be any general stoppage and, except where repairs are necessary, all plant will be kept running at full capacity. The demand for both light and heavy material is urgent. The raw material position is quite satisfactory at present and a large tonnage of scrap has been coming in of late; good shipments have arrived from overseas. The steel export Order still prevails and, at the moment, it is doubtful whether any exports will be permitted this month. The following are the current quotations:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, $\frac{3}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton, and weighing under 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton all delivered at Glasgow stations.

Malleable-Iron Trade.—Active conditions are general in the West of Scotland malleable-iron trade and plant is fully occupied. The demand for re-rolled steel bars continues to be strong and the re-rollers have ample supplies of semies as large tonnages have recently arrived from overseas. The stocks on hand are now much larger than they have been for many months and the works are running at full capacity. The market quotations are as follows:—Crown bars, 14*l.* 2*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There has been no change in the state of the Scottish pig-iron trade during the week and although the output is on a very large scale, the whole of the iron produced goes quickly into consumption. The steel works, in particular, are taking a heavy tonnage. Foundry grades of iron move rather more slowly, but quite a fair demand exists. To-day's prices are as follows:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

ROAD BRIDGES IN NEW SOUTH WALES.—Since 1925, the Department of Main Roads, New South Wales, has constructed 911 bridges, the total length of which is 16¼ miles, and the cost, 2,483,879*l.* *The Commonwealth Engineer* states that considerable effort has been made to maintain the standard of design abreast with the most modern practice developed in Europe and the United States. Many of the bridges are of the reinforced-concrete framed type or of the slab-concrete type.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Conditions in the iron and allied trades leave but little material for the usual industrial purposes, and ordinary commercial transactions are now on a small scale. The aggregate tonnage output remains at a record level and pressure on the resources of producing plant is still increasing. The issue of licences to obtain commodities and the allocation of supplies over the third quarter of the year are engaging active attention and operations under the control scheme promise to work smoothly. Regular deliveries of tonnage, over fixed periods, are assured.

Cleveland Iron Trade.—The supply of foundry iron is keeping pace with the expanding demand, but consumers are largely dependent on day to day deliveries from other producing centres. The irregular small make of Cleveland pig has now been discontinued. Founders in this district are, however, receiving some iron from Scotland, and arrivals from the Midlands are continuing on a scale that meets current requirements.

Hematite.—The statistical state of the East Coast hematite branch of trade is receiving careful attention and action is likely to be taken to deal with the situation. Producers are continuing to provide for the actual requirements of consumers and hope to increase their output to cope with the heavy and growing demand. As, however, their delivery obligations are extensive they are not anxious to discuss new business. Buyers are pressing for full contract deliveries and are taking up a considerable proportion of the large make, but the bulk of this is passing into use at the producers' own works.

Basic Iron.—Steelworks owned by basic-iron producers continue to absorb the whole of the output of the basic blast-furnaces.

Foreign Ore.—The position regarding supplies of foreign ore is under close and constant review. Consumers are carrying more stocks than usual and report that imports are quite satisfactory.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is little heard of. Local users are well covered and sellers are disinclined to accept further orders.

Manufactured Iron and Steel.—The increased make of semi-finished iron and steel and satisfactory imports of American semies are meeting the requirements of re-rollers. There is a steady expansion of finished-iron production and makers of all descriptions of steel are obliged to operate their plant at its full capacity in order to deal with the demand.

Scrap.—An appreciable increase in the deliveries of iron and steel scrap can be reported, but further supplies are still needed.

TROLLEY OMNIBUSES FOR WOLVERHAMPTON.—Messrs Sunbeam Commercial Vehicles, Limited, Moorfield Works, Wolverhampton, inform us that the Wolverhampton Corporation Transport Department has recently placed an order with them for ten Sunbeam-B.T.H. trolley-omnibus chassis of the M.F.2 four-wheel type. This, we are informed, is the twelfth repeat order which this transport department has placed with the Sunbeam Company since the first vehicles were supplied some nine years ago.

AEROPLANE RECOGNITION TESTS.—In order to facilitate the identification of belligerent aeroplanes, an attractive little pamphlet has been published by *The Aeroplane*, Bowling Green-lane, London, E.C.1. This, which is entitled "*The Aeroplane* Recognition Tests," contains 44 reproductions of photographs comprising British bombing and fighting land and seaplanes, French military machines, and Heinkel, Dornier, Messerschmitt, Blohm und Voss and Junkers aeroplanes. All the aeroplanes are shown in flight and an identification key, which includes data on the types of engine carried and the top speeds of the aeroplanes, is included. The price of the pamphlet is 6*d.* net.

PISTONS FOR MOTOR-CAR ENGINES.—Unless there is to be a marked loss in power when a petrol engine for road-vehicle work is converted to operate with gas from a portable producer, it is necessary to raise the compression. This is most readily effected by fitting new pistons, and Messrs. Specialloid, Limited, Friern Park, North Finchley, N.12, have sent us some particulars of an extensive range of pistons suitable for the majority of the vehicles which are being converted at the present time. These pistons embody a special form of head designed to promote turbulence, and are designed to give the most efficient compression ratio for the engine to which they are fitted. The pistons are provided with a wide first land, cast relief on the skirt, and oil scraper rings both above and below the gudgeon pin. In some cases in which the design of the engine does not lend itself to the replacement of the pistons, the firm supply special cylinder heads.

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

(*For Description, see Page* 13).

FIG. 1. EXTERIOR OF SOUTH STATION.

FIG. 2. BRIDGE OVER RUE SALLAERT.

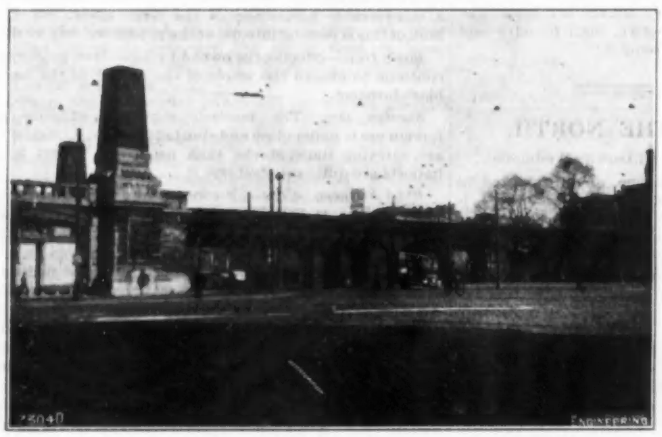


FIG. 3. VIADUCT OVER BOULEVARD DU MIDI.

FIG. 4. TUNNEL END OF SOUTH VIADUCT.

FIG. 5. EXTERIOR OF NORTH STATION.

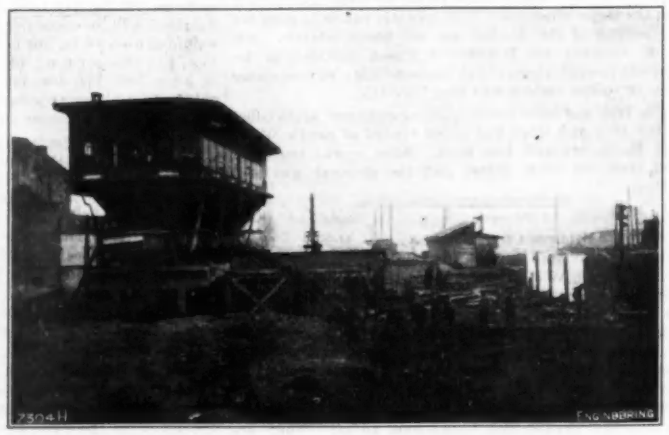


FIG. 6. NORTH STATION SIGNAL BOX IN NEW POSITION.

FUEL FOR GAS PRODUCERS IN ROAD VEHICLES.—The British Coal Utilisation Research Association, Rickett-street, London, S.W.6, informs us that supplies of Suncole and Motor Coalite, both of which fuels have given excellent results in road-vehicle gas producers, have recently been supplemented by the production of two other fuels, namely, Rexco and Oco. The first is manufactured by Messrs. Coal Research Syndicate, Limited, Mansfield, Nottingham, while Oco is produced by Messrs. The Ocean Coal Company, Limited, Cardiff. We are informed that these two fuels have been certified by the Association as conforming to the specification of the Producer Gas Fuels Committee of the Coal and Carbonisation Industries and that extensive road trials, as well as chemical tests, have been carried out. It is added that Oco is at present available only in small quantities from a pilot plant, but that production on a commercial scale is to be gradually developed.

CYLINDER-LINER WEAR.—Some interesting measurements on cylinder-liner wear have recently been published by Messrs. The National Gas and Oil Engine Company, Limited, Ashton-under-Lyne. The engine on which the measurements were made was one of the firm's "B.A.R." type with a piston diameter of 16 in. This engine is unusual, in view of the moderate piston diameter, in being fitted with oil-cooled pistons. The first engine of this type was built in 1935 and has completed 22,000 hours running time, the average load factor being 86 per cent. One liner, that of No. 5 cylinder, was changed after 19,000 hours running, but the remaining liners are as originally fitted. Measurements showed that the maximum diameter of the cylinder at the top of the stroke, for cylinders Nos. 1 to 6, respectively, was 16·0105 in., 16·013 in., 16·016 in., 16·017 in., 16·002 in., and 16·013 in. The wear thus varies from approximately 0·0005 in. to 0·00075 in. per 1,000 hours, the average being 0·00063 in. per 1,000 hours. As wear may be greater at low than at high loading, these figures may be compared with those obtained with a similar engine which ran for 11,000 hours on a load factor of only 38 per cent. In this case, measurements showed that the lowest wear was 0·0006 in. per 1,000 hours, and the highest 0·0013 in. per 1,000 hours, the average being 0·00095 in. per 1,000 hours.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

For the United Kingdom	£3	5	0
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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, JULY 5, 1940.

VOL. 150. No. 3886.

WORKING HOURS AND REST PERIODS.

THE encouraging figures relating to the increased output of various types of munitions, which Mr. Morrison was able to quote in the House of Commons on June 27, give some measure of the magnificent response made by industry to the appeal for increased production which was made some two months ago. In that period, many new workers have come into the munitions industries. They will have helped towards this excellent result; but as new labour, and especially when unskilled or only semi-skilled, must require a little time to take its place effectively as a producing force, the increases quoted, varying from 50 per cent. to 420 per cent., must be credited in the main to the employees and the managements associated with them who have been carrying the burden of armament manufacture over many months. These results have been achieved by increased personal effort, increased hours and the abandonment of holidays; but excellent as they are, they are not the end. The most that Mr. Morrison would allow himself to say was that, although things were not yet satisfactory, satisfaction was coming nearer.

How long the workers will be able to maintain the quality of their present effort is a grave question. Up to a period, zeal and enthusiasm may spur a worker to exertions far surpassing those of everyday life, but there must come a time when physical strain will prove stronger than the most determined will power. As the physiologists say, the limiting factor is the vaso-cardiac efficiency. During a rest period, following one of strain, the blood pressure and pulse rate return gradually to normal. The greater the previous strain, the longer the necessary interval of rest, and it well may be that when long hours are worked over seven-day weeks for many months, a condition may be reached in which the possible rest period is too short to enable these physiological functions ever to return to normal. To put it in shop terms, there must be a length of working week—speaking always in terms of an extended period—which will actually show a smaller output than would a shorter week. What is the optimum week from the point of view of output, which to-day is the sole consideration, is not known.

In our issue of May 17, we gave some account of a recent booklet compiled by the Industrial Health Research Board, and entitled *Industrial Health in War*. This publication pays some attention to the question of working hours and output, but, as was pointed out in our previous article, its evidence that a reduction in hours may result in an increase in output is confined to a single case and one in which the work-people were standing about waiting for material for a time equal to 24 per cent. of the time they were working. This example proves nothing, but, as it is the only one that is given, it does suggest that the Industrial Health Research Board, which has had twenty years in which to do the work, has made no effective investigation into the question of the optimum week, and that it knows no more about the subject than the average works manager; probably less. The matter is one quite suitable for scientific research, but as neither twenty months, nor twenty days, much less twenty years, are now available for any such investigation, we shall have to carry on without knowing what this best week is.

In his speech to which we have referred, Mr. Morrison said, in connection with production, that he was not going to pursue any particular pet theory; he wanted output. This is the admirable spirit and point of view which has been adopted by those responsible for carrying on our numerous and varied munition factories. They may not know what the optimum week is, but, at the end of some two months of unexampled strain, are experimentally feeling their way towards such modifications of hours as will give some relief to the workers without adversely affecting output. In one of the vital branches, a leading firm, which has been working a seven-day week over many months, has recently been giving its workers every alternate Saturday afternoon off. No doubt there are many works which have done this from the beginning of the period of pressure, or have left every Saturday afternoon free, as was fairly common in the munitions drive of the last war, but the incident illustrates the tentative and practical investigation of the optimum week, which alone is now possible. The recent announcement by Lord Beaverbrook that workers in aircraft and engine factories, and on components, shall have one day off each week, is further evidence of the practical examination of this question. The matter of actual holidays will, no doubt, be dealt with in due course in the same spirit of careful empiricism. It is clear that greater freedom in the re-arrangement of shifts, so as to reduce the length of the week for the individual workers, will become possible as the stream of new workers increases in volume. The satisfactory progress of one source of supply was indicated by Mr. Bevin last week, when he stated there were now 10,700 trainees in the Government training centres, 2,000 more than a fortnight earlier.

Apart from the adjustment of hours and the granting of holidays, considerable experience is available which suggests that the morale of work-people may be improved, with beneficial effects on output, by introducing definite rest periods into the working day. In the leading article in our issue of June 7, we referred to the possibility of arranging tea-and-sandwich services at about half-shift. Something analogous has been in operation in many factories for a considerable time. Organised rest pauses are introduced into the working day—in some cases in the morning, in others in the afternoon, sometimes in both. It is not unusual in any factory for a rest pause to be introduced by the individual worker for his or her own benefit, and in many cases it has been found advantageous to organise the procedure and introduce official periods of some ten minutes or so, during which work is suspended. A report on this subject entitled *Rest-Pauses and Refreshments in Industry* was published by the National Institute of Industrial Psychology towards the end of last year. It recorded the results of enquiries made at 1,050 factories in Great Britain. These were situated in and around London, Cardiff, Birmingham, Manchester, Leeds, Newcastle-upon-Tyne and Glasgow, 150 factories

being dealt with in each area. The works covered a wide variety of industries, and ranged in size from five employees to 12,000. The average was 290. The total number of employees concerned was 305,000, of which 183,000 were men and 122,000 women.

The results of the investigation showed that 24·7 per cent. of the factories had official rest pauses in the morning and afternoon; 18·2 per cent. in the morning only; 2·2 per cent. in the afternoon only; and 7·8 per cent. at times within the discretion of the individual worker. In 14·7 per cent. of the factories, unofficial rest pauses were taken, probably in most cases having grown up as a trade custom, tacitly permitted although not officially recognised. In 32·4 per cent. of the factories, there were no rest pauses. Considerable differences were shown by the different areas. Thus, in London, no less than 77·3 per cent. of the factories had official rest pauses of one or other of the classes mentioned above; the corresponding figure for Glasgow however, was only 41·4, and for Leeds, 31·3. These differences need not be taken as evidence of a less enlightened policy of the management of the factories in the northern towns. Many factors influence the matter. The hour of starting work is frequently earlier in the north, a break of half-hour being allowed for breakfast. This was not recorded as a rest pause, but clearly in many cases would render an official rest pause unnecessary. Further, the heavier type of work, more common in the factories of Glasgow or Leeds, does not lend itself to temporary stoppages in the same way as the lighter type of repetition industry so common in London.

In the majority of cases it was found that the rest pauses were spent in the workroom and were used for the consumption of refreshments. In 15·5 per cent. of the cases the food was paid for by the employer, the corresponding figure for drink being 37·6 per cent. Tea was the most popular beverage, followed by milk. It is of considerable practical interest at the present time, that in many cases the rest pauses and accompanying refreshments were introduced because it was found that large numbers of the younger women came to work without having had adequate breakfasts, so that within two hours or so decided flagging was noticed. Men seem to look after themselves better. The rectification of the household arrangements of these factory women is a matter for the social worker. The works manager has no time to investigate that subject, but if he can obtain more continuous attention to work and better output by supplying tea and sandwiches in the course of the morning the expense and trouble will be repaid. That this rather domestic consideration is an important one is made clear by the fact that 30·7 per cent. of the factories concerned stated that they had introduced refreshments because employees arrived after inadequate breakfasts.

In view of the present drive to introduce more and more women into the munition factories, this matter is of importance. Mr. Bevin has announced a scheme for the employment of part-time women workers, who would attend the factories for one or two days a week and so provide a break for the regular workers. As it is probable that the majority of such women would be new to factory life, and, unless nursed to some extent, might find the conditions beyond their power of endurance, it would appear desirable that something on the lines of this rest-period system should be introduced for their benefit. Such part-time women, who would probably be drawn from all classes, might be expected to display an admirable enthusiasm, but this in itself would not be sufficient. The continuous operation of a machine tool, or the carrying on of an assembly operation, for hours at a stretch induces a type of strain entirely new to women familiar only with the routine of household duties. Something on the lines of the "elevenses," which most of them seem to find essential even in the home, might make all the difference between success and failure in their new duties. The rest-pause system will not eliminate all the difficulties arising from unduly long hours, which may have to be faced for many months, but it should form a valuable contribution towards their solution.

THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

IN normal times one of the most valuable of the engineering functions which take place during the summer months is the Annual Convention of the Incorporated Municipal Electrical Association. It is also one of the largest, for though, strictly speaking, the membership is confined to those connected with municipally-owned electricity supply undertakings, the meeting attracts, as visitors, representatives of most branches of the profession and industry. The official discussions, therefore, reach a standard quite worthy of the excellent papers that are presented, and not all of which are written by members. Moreover, as is true of many other such gatherings, the unofficial deliberations, which take place among kindred spirits, are often even more productive. Indeed, the time is so fully taken up with problems of technical interest and social relaxation that what may be called the trades-union side of the Association's activities tends to become obscured. Thus, the annual general meeting is relegated to the last day of the convention and, except when, as in recent years, something like the McGowan report has engendered some heat, the deliberations are mainly formal.

The war has changed all this. In the first place there were many reasons why a full-dress Convention could not be held this year. There was some opposition even to a truncated gathering, such as took place during the last war, being held in London; and, finally, it was decided to limit the proceedings to the annual general meeting. Even this, owing to the position in France, had to be postponed from Thursday, May 30, to Thursday, June 20, when it took place at Grosvenor House, London, under the chairmanship of the President, Mr. J. Mould, general manager of the city electricity department, Leicester. Nevertheless, the attendance was fairly satisfactory and the proceedings were enlivened by a discussion on four matters of administrative interest, not all of which can be described as war-time problems. This discussion, it may be noted, took place in spite of the President's suggestion that members might be too pre-occupied to deal with such matters. As has happened in other spheres, however, the rank and file were more enterprising and perhaps more realistic than their leaders.

The first motion dealt with the effects on electricity supply, not of the Germans but of an even more incalculable force, the weather. It will be no news, as it is now permissible to record, that during the last two winters this country has suffered from spells of more than usually severe weather. The result has been an inordinate upheaval in the peak loads of many undertakings, especially those supplying areas in which the domestic load is predominant. This was due, of course, to the increased use of electric fires, instead of or in addition to the older methods of heating. Such an increase, however, instead of being a benefit to those concerned, tended to be more or less a temporary embarrassment, for the majority of undertakings in the country are now receiving their supplies directly or indirectly from the Central Electricity Board and are paying for them at the Board's tariff. This tariff imposes, *inter alia*, a fixed charge on each kilowatt of maximum demand, this maximum demand being taken to be twice the largest number of kilowatt-hours supplied during any half-hour in the months of January, February, November and December. The effect of a sudden demand for heat which may last only for a short time each day is, therefore, to impose a disproportionate financial burden on the undertaking.

This disability, which is not altogether new, has been discussed with the Central Electricity Board without much effect. The object of the resolution proposed by Mr. C. C. Kirby at the meeting was therefore to carry the matter a stage further: the suggestion was that the annual kilowatt charge should be based on the average of the maximum demands in the four winter months, even if that meant some alteration in the existing charge per kilowatt. Mr. Kirby explained that, as it was impossible to arrange a tariff for domestic purposes on the same lines as the grid tariff, the undertakings were left unprotected against increasing loads due to domestic consumption and were, therefore, faced with considerable loss due to cold "snaps." Such domestic peaks, which were likely to become more prominent with the increasing use of electricity for heating and cooking, had a very poor load factor and their unfair effect should be recognised. Rather surprisingly, perhaps, Mr. Kirby did not receive a great deal of support for his views, though as the matter was finally left in the hands of the Council for consideration it may be presumed that they have some substance. Alderman W. Walker, who is a member of the Central Electricity Board, pointed out that the Board only acquired some 73,000*l.* extra revenue as a result of the cold spell. In 1939, it may be mentioned, its total revenue was nearly 38,000,000*l.* The Board, Alderman Walker added, based their estimates of plant capacity on the undertakings' own estimates of requirements, and, if the load estimated was not utilised, the difference did not have to be paid for. He suggested that this difference might be paid into a balancing fund, a course which has much to recommend it if the temptation to overestimate can be resisted. He was strongly supported in this view by Mr. A. E. McKenzie, although Wimbledon had suffered severely from the cold snap, and by Mr. W. P. Litwall, who pointed out that undertakings without generating plant did not require large reserve funds. These could be used, therefore, to balance up the charges incurred in exceptional winters. Other speakers followed in the same sense, with the result that we have already recorded. It may, however, be noted that the Board's tariffs are due for revision in 1943, and that, though much may have happened in the meantime, this is not too long a period in which to prepare a case for the removal of anomalies.

The increased use of electric heating also received attention from another point of view in a second motion. This was proposed by Mr. J. N. Powrie, who suggested that in the event of the reintroduction of rationing the Government should remember that the use of raw coal for domestic heating involved an enormous amount of transport and retail distribution, while the employment of electricity for this purpose would reduce this both in bulk and in "spread." Actually, this point was made by the gas industry, though not, for some reason, by the electricity supply industry, when rationing was being considered by the Secretary of Mines last year. Its soundness is emphasised by the fact by the eagerness with which consumers turned to electric heating last winter, when an extended cold spell disorganised the coal supply. Mr. Powrie argued with some force that the Government had reason to be grateful to electricity undertakings for providing a supply of heat under these conditions. It must be emphasised, however, that a reintroduction of rationing might prevent them from affording similar help next winter. This resolution, it is perhaps needless to add, was carried unanimously.

For the rest, Mr. H. Wilson of Ashford wished the Association to approach the Electricity Commissioners with a view to obtaining authority to instal stand-by generating plant which could be used in event of enemy action putting normal methods of supply out of action. He contended that this was a more economical alternative than arranging for a duplicate supply from the grid. Mr. J. W. J. Townley, however, opposed the motion on the grounds that the Commissioners were willing to consider specific cases and that the Central Electricity Board was not averse from the idea of Diesel plant when it was deemed appropriate. Mr. E. E. Hoadley also drew attention to the difficulty of obtaining Diesel plant under existing conditions. As at the present time the problem borders on the strategic, it is perhaps as well that the resolution was rejected. It has, however, another aspect, and we hope that we are not unduly suspicious in presuming that it might have been an attempt by certain peculiarly placed undertakings to rid themselves of what they feel are the unduly restraining shackles of the Central Electricity Board.

NOTES.

MACHINE TOOLS AND MUNITIONS MANUFACTURE.

IN the course of a statement which he made in the House of Commons last week, the Minister of Supply (the Rt. Hon. Herbert Morrison, M.P.) made reference to the provision of machine tools which were, he said, an element of profound importance in the successful conduct of hostilities. The various sources of supply were the manufacturers, the owners of second-hand tools and foreign purchases. Steps were being taken to increase the rate of production from 10,000,000*l.* to 15,000,000*l.* per annum, and thoroughly to comb out all second-hand tools. Tools to the value of 1,500,000*l.* a month were also being imported. Dealing with the census of machine tools, mention of which has already been made in ENGINEERING, he said that the Controller of Machine Tools had been given powers to requisition any plant which was idle and could be put to effective use. In these ways tools were being made available at the rate of 80,000 per annum and would be allocated in accordance with priority of production and order. It was important that there should be relativity between machine-tool use and the kind of munitions that should come first. He added that machine tools bought abroad for employment in France had been diverted to our own use; when the list of orders was completed it was estimated that it would be well over 3,000,000*l.* Dealing with the question of research, in the same speech, Mr. Morrison said that proper machinery existed for the examination of all proposals of a scientific and inventive character. The scientific research department, under Dr. H. J. Gough, and the Advisory Council, under Lord Cadman, had done splendid work for the Ministry.

RESOURCES OF MAN POWER.

Many engineers above military age feel a little impatient that they have not yet been able to find a place in the extensive industrial effort now occupying so much of the energies of the country. Although it is possible that some of them hardly allow for the considerable time required for the organisation of new sources of supply, or the extensive enlargement of old, it is equally possible that the services of some of these men have not yet been utilised because those responsible for the operation of newly-created departments of vast extent do not realise that they are available. It is presumably with the idea of ensuring that the wastage represented by useful men chafing in inactivity shall be eliminated, that the Minister of Labour has appointed Sir William Beveridge as a commissioner to survey the available resources of man power of the country. The precise form of the survey to be undertaken has not been disclosed, and it is possible that Sir William himself does not yet know into what ramifications it may lead him, although, as the enquiry is to cover men, women and young persons, it is clear that if too detailed a survey is attempted unjustifiable time may be consumed. Confining comment to our own sphere, however, we may suggest that a comparative analysis of the detailed statistical information already in the possession of the great engineering institutions will give reliable information about most of the skilled engineering experience still waiting to be utilised. Mr. A. Reeder, Deputy Director of Statistics in the Ministry of Labour, will act as secretary to the survey. Since the announcement of Sir William Beveridge's appointment, it has been stated that a committee is being formed, comprising women Members of Parliament and representatives of various women's organisations, for the purpose of establishing suitable machinery to deal with the influx of women into the war industries.

THE TIMBER SUPPLY POSITION.

The economics and finance of the timber trade were discussed by Major A. I. Harris, Timber Controller to the Ministry of Supply at a Press Conference held on Monday, July 1. The whole of Europe, from which in peace time came a preponderance of our timber, he said, had been cut off as a source of supply, but negotiations were in progress between ourselves and Russia with a view to improving this position. Further chances of betterment came from the assistance which was being provided by the Dominions and Colonies. In spite of teething troubles and the unfavourable weather in the spring, Canada was sending us a tremendous number of pit props and he felt certain we should succeed in getting the much greater production we undoubtedly needed from that country. Supplies from Newfoundland were fully up to every foot that was promised. This was an extraordinary achievement when the amount of labour which had been transferred to this country was considered. We were importing now, and this would continue in the coming months, a larger quantity of timber than we had imported since the war started; and it was fully equal to our essential requirements. By the end of the month, 100,000 tons of timber would have been carried by rail from British Columbia to the eastern ports of Canada. Turning to home production, Major Harris said that this was steadily increasing. The total production of mining timber by the Forestry Commission and the timber trade was now some millions of tons per annum. In this connection, the biggest limiting factor was scarcity of labour, and there was work for men who had been engaged in building, shop fitting, joinery and furniture and cabinet making. A special section of the Department had been set up to deal with the plywood needed in aircraft manufacture. The demand for timber for munitions, combined with the difficulties of supply, would naturally limit its use for other purposes and increases in its price by anything from 20 per cent. to over 100 per cent. would be imposed. The employment of timber for furniture, shoes, packing cases and other civilian purposes would be restricted, though the manufacture of a sufficient supply of sports goods and of simple wireless sets would be encouraged.

INCREASE IN LONDON ROAD TRANSPORT FARES.

When the railway companies were recently permitted to increase their revenue by adding 10 per cent. to their charges, the road services of the London Passenger Transport Board were excluded from the arrangement, owing to the difficulty of adding that percentage to the small basic sums involved. As, however, the Board is a partner with the railways in the war-time financial arrangements with the Government, some means of raising the additional revenue required—about 2,000,000*l.*—had to be found. The matter was, therefore, referred to the Charges (Railway Control) Consultative Committee, who eventually reported in favour of the policy of raising all existing 1*d.* fares to 1½*d.* In addition, it was recommended that existing 1½*d.* fares should be increased to 2*d.* and 2*d.* fares to 2½*d.* Before coming to this decision, the Committee stated, they considered all possible alternatives, including the retention of the 1*d.* fare for one stage instead of for two, a solution much favoured by one school of thought. The reasons given for rejecting this course were that, while a 'bus takes only 3 minutes to travel one stage, the conductor requires 4½ minutes to 6 minutes to collect the fares if the vehicle is reasonably well loaded. Moreover, about 30 per cent. of the 1,500,000 daily penny passengers only travel for one stage, instead of the two stages to which they are entitled, and it was estimated that, if 1*d.* was charged for one stage and 1½*d.* for two, this number would be increased to 2,500,000 per working day, owing to passengers walking a few hundred yards at one end of the stage or the other to avoid payment of the additional fare. Such a state of affairs, it was considered, would place too great a burden even on the present expert conductors, and the position would become worse in the near future if and when less efficient substitutes have to be employed owing to war-time conditions. Workmen's fares are not increased, except that the minimum will be raised from 2*d.* to 2½*d.* Coach fares, however, are being increased by 10 per cent. to bring them into line with the railway fares, and the 1*d.*, 1½*d.* and 2*d.* fares on the Board's railways are also raised by ½*d.* in each case. It cannot be said that this is an ideal arrangement, although it is perhaps the best that could be devised in the circumstances. The changes came into force on Wednesday, July 3.

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

THIS article, supplied by a correspondent in the Low Countries, was in an advanced state of preparation when Belgium was invaded. As a result of that event, work on it was suspended. In view, however, of the occupation of the country by the Germans, there is now no military objection to its publication. It is of interest to note that the great undertaking which is described has twice been interfered with by German occupation. As explained in the article, the work was inaugurated in 1903 and considerable progress had been made before the invasion of 1914 resulted in a suspension of all activity. It may be assumed that the present German occupation has again stopped work, although information on the subject is not available.

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From the point of view of railway transport, Brussels occupies a more favourable position than do most capital cities. The map reproduced in Fig. 7, on page 14, shows that seven main railway lines, fairly evenly spaced around its periphery, radiate from its two main stations, Brussels North and Brussels South. These connect to all parts of Belgium, and most give direct access to adjacent countries. The four lines based on the North station are the Ghent-Ostend line connecting with the channel service to Dover; the Mechlin-Antwerp line, providing connection to Holland; the Louvain-Liége line leading to Germany; and the line through Namur to Luxemburg. From the South station, there is the line to Charleroi and the South Belgian industrial area; the line to Paris, with connection to Alt, Lille and Calais, providing an alternative route to Dover; and the line to Ghent which connects with the corresponding line from the North station at that town and provides connection to Ostend. This alternative line to Ghent has been in operation only since 1933.

The basing of all these main lines on Brussels has the result that through connection between provincial towns on different sides of the capital is not altogether satisfactory. It frequently involves long waits for suitable connections, or the crossing of Brussels by road vehicle from one main station to the other. The desirability of providing railway connection between Brussels North and Brussels South was realised long ago and the western ring line passing through Brussels West, which is shown in Fig. 7, has been in service since the year 1871. Unfortunately, this line was planned in 1866, and, being laid out with curves of 500-m. radius in the open country and 350-m. in the vicinity of the stations, is unsuited for modern passenger traffic. Speed is limited to some 28 miles an hour. The distance between the two main stations by this route is 11 km., the direct distance in a straight line being only 3 km.

As will be seen from the map, there are two ring lines on the eastern side of the city, but neither connects directly to the South station. The inner one, which passes through the station situated in the Leopold quarter of the city forms part of the main line to Namur and Luxemburg, which was opened in 1854. The outer ring line, which has been in service since 1930, is well suited for express passenger traffic, but, as will be seen, the connection it provides between the North and South stations is very indirect. Two short junction lines, in the neighbourhood of Watemael and Linkebeek, are being provided to connect this line more directly with the South station. They are indicated by broken lines in Fig. 7. The difficulty of using these ring lines in connection with main-line services is accentuated by the fact that the North and South stations are both termini, and for many years the construction of a short junction line between them has been advocated. This, by converting them to through stations, would provide a direct and short connection between the main lines now serving the North station and those serving the South.

During the period 1841 to 1855, there was a direct north-south junction railway through Brussels. This connected the Groendreef and Bogarden stations. The Groendreef station, which is situated a little to the west of the North station, is claimed

to be the oldest railway station on the Continent. It is now used entirely as a goods station, passenger traffic having been transferred to the North station, which was constructed at a later date. The Bogarden station, which no longer exists, was situated about a kilometre to the north of the position now occupied by the South station. This early junction railway ran through the town at street level, skirting the canals which pass down the western side of the city and connect to the Maritime Canal, which is shown in Fig. 7. This line was abolished in 1855; owing to the increasing road traffic in what was at that time the harbour quarter of Brussels, the railway had become a source of inconvenience and danger. The closing of this railway was not carried out without opposition, and in 1856 the Municipal Council petitioned the King for the building of a new direct railway connection through the town. One proposal at that time was for the construction of an elevated line, but the opposition to this on æsthetic grounds was so great that it was dropped. Actually, it was not until April 7, 1903, that agreement was come to between the Brussels Municipality and the Belgian State for the building of such a railway. The plans of that time still form the basis for the works which are in progress. The route of the line is shown in the map reproduced in Fig. 8, on the opposite page.

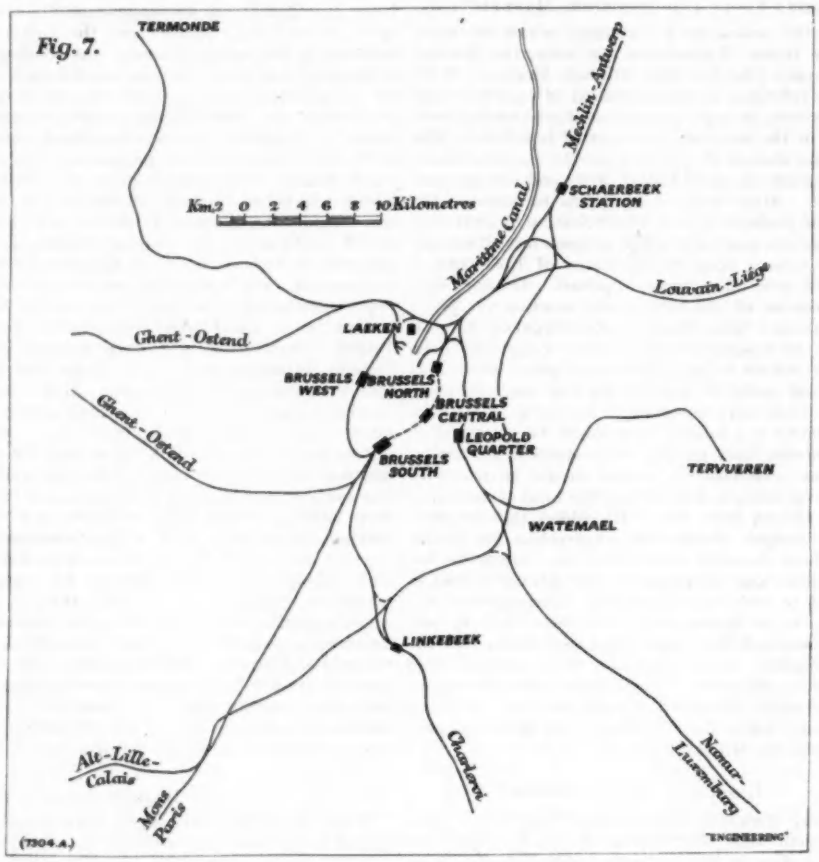
LAYOUT OF THE JUNCTION RAILWAY.

After the signing of the agreement in 1903, work was at once put in hand and much property was purchased and demolished at the south end of the line. As will be seen from Fig. 8, the section of the railway between the South station and the Place de la Chapelle, which has a length of 861·9 m., is in the open. Beyond this, the line enters a tunnel. Work on this southern section was in an advanced state when Belgium was invaded in the early days of the Great War of 1914-1918. This naturally resulted in the suspension of all work. After the declaration of peace, all activity available for railway work had to be directed to repairs and reconditioning on the existing railway system. The period following this was marked by the world slump, and in 1921 the Minister of Railways introduced a Bill directing the suspension of work on the junction line. Although this Bill was not passed, opposition to the spending of funds on the project was so great that the work was not seriously taken in hand again until the end of 1935. In that year the financial position had so improved that the necessary moneys for the work were available; an additional reason for the resumption of the construction was that it provided a useful method of absorbing unemployed labour. A law was passed on July 11, 1935, which created a National Bureau, under the direction of which work was resumed.

The junction line which is now being completed has a total length of 3·1 km., of which about two-thirds is in tunnel and the remainder either in cuttings or on viaducts. As will be seen from Fig. 8, there are open sections of the line at each end. The strip of ground occupied by the railway works has an average width of 50 m., and as all buildings on this strip, including those above the tunnel, had to be pulled down, it is fortunate that the line runs through a part of the city of little architectural interest. Its construction will permit of considerable improvement in the central area and the opportunity is being taken to make a new main avenue, 22 m. in width, which will greatly improve the road connections between the northern and southern parts of the town. As both the North and South stations will be approached on viaducts, and as these stations are both situated at ground level, it will be necessary to raise them. The reconstructed North station will be 8 m. above the present position, the corresponding figure for the South station being 6 m. A new Central station, situated below ground level, is being constructed at about the mid-point of the junction railway. This site is indicated in Fig. 8. There will also be two passenger halts, one at the Place de la Chapelle and the other at Congrès, just north of the Botanic Gardens. The reconstruction of the North station will enable the old Groendreef station to be demolished, liberating some 17¼ acres of ground for building purposes and abolishing three level crossings in a populous neighbourhood.

NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

Fig. 7.



To understand the construction of this new line, partly on viaducts and partly in tunnel, it is necessary to have some knowledge of the natural land formation in the area. Brussels, with its suburbs and adjacent townships, has a population of about one million, and grew to its present size from an insignificant village situated on the banks of a small stream, the River Zenne, the position of which is indicated at the lower right-hand corner of Fig. 8. This stream runs in a South West-North East direction at the bottom of a low valley. Some 300 m. from the right bank, the land rises fairly steeply to form a range of hills. The newer part of Brussels is built on these hills, the summit being roughly marked by the eastern boulevards. The considerable differences of level existing in the town are illustrated by the fact that the Rue Neuve, to be seen in the lower part of the left-hand end of Fig. 8, is situated on contour line 17, but the Rue Royal immediately above, at the top of the figure, is situated on contour line 54. As the main stations are both situated between the river and the hills, a straight connecting line between them would have lain largely in the river bed, which, owing to the alluvium and peat formation, would have been an unsuitable position for constructional work. Such a position would also have been unfavourable from the point of view of town layout.

The position proposed in the original layout, and which has been adopted, diverts the railway to the east so that for two-thirds of its length it passes through a tunnel inside the hill. It lies on a contour line approximately midway between those of the Rue Neuve and the Rue Royal, and the maximum gradient is 5 in 1,000. The arrangement adopted has the advantages that, for the greater part of its length, the line is hidden from view, and that the formation, consisting of wet, but hard, sand, is quite suitable for constructional work. A disadvantage of the original scheme was that the line would have passed directly below the Church of St. Gudule. This is an historic building of great importance and beauty, and it was not possible to permit the adoption of any measures which might have endangered it. As will be seen from Fig. 8, the difficulty has been overcome by taking the tunnel round the church on a curve. At the nearest point, the tunnel is 60 m. from the church-tower foundation. Another historic building, the Kapellekerk, is also situated close to the line of the tunnel, but in this case it was considered sufficient to take special precautionary measures during the construction work. These proved to be entirely adequate.

The agreement of April 7, 1903, covered the following items:—

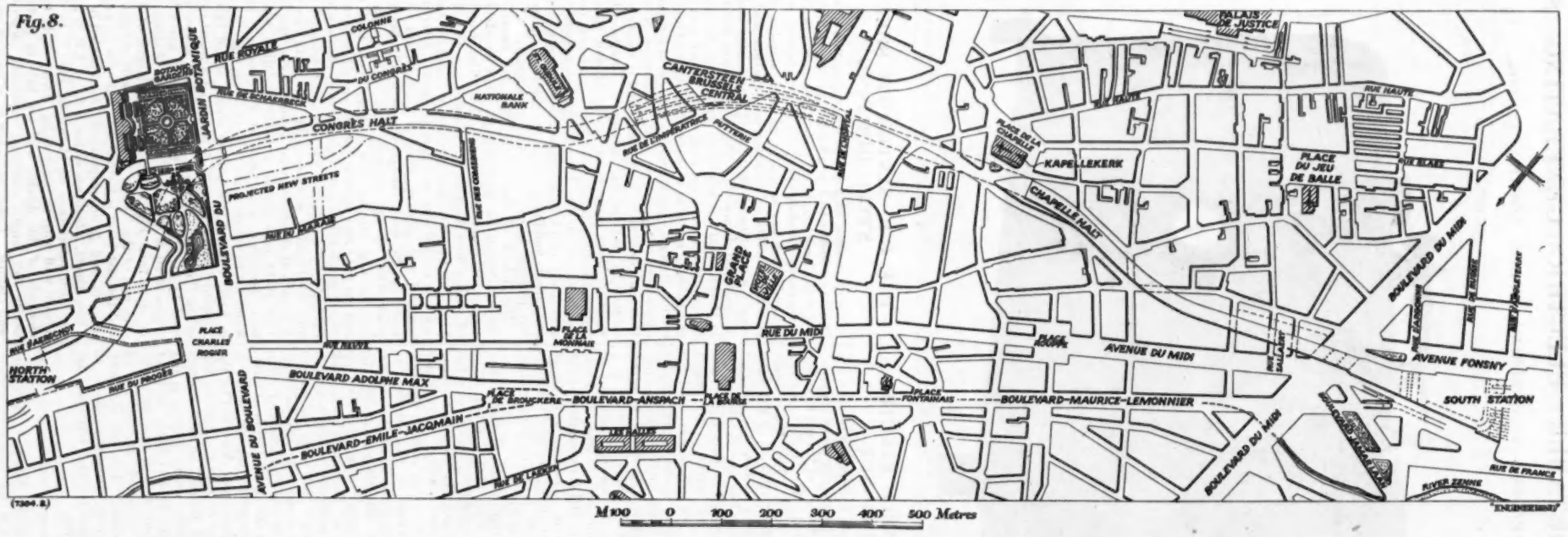
(*a*) The complete rebuilding of the South Station, the level of the new station being 6 m. higher than that of the existing station. This involves the diversion of the River Zenne in the neighbourhood of the new works. The diversion has already been carried out and the filling of the old bed is in progress. A view of the front elevation of the old station, which will be entirely replaced by new buildings, is reproduced in Fig. 1, on page 10.

(*b*) The building of a series of viaducts, carrying six railway tracks, passing over a number of streets and avenues, and extending from the South Station to the Place de la Chapelle. At the time of the invasion in 1914, these viaducts were in an advanced state. They are of various types, brickwork, reinforced-concrete and steel construction all having been employed. The bridge over the Rue Sallaert is illustrated in Fig. 2, on page 10. The abutments for this bridge were completed in 1914, but the arch was not built until 1937. The viaduct across the Boulevard du Midi is shown in Fig. 3. The closed-in portion, the beginning of which can be seen to the left of the figure, will be occupied by shops. Another view, showing the viaduct just before it connects with the south end of the tunnel, is given in Fig. 4. The two arches on the left form part of the new retaining wall. This view shows the Kapellekerk in the background.

(*c*) The construction of a six-track tunnel from the Place de la Chapelle to a point alongside the Botanic Gardens. This section has a length of 1,948 m. A halt, with a single platform 200 m. long, and between the eastern pair of tracks, will be constructed at the Place de la Chapelle. All

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

Fig. 8.



slow traffic will utilise this pair of lines. The platform will be connected with the street level by staircases. At a distance of 650 m. from the south end of the tunnel, the Central Station will be built. This will be situated close to the Putterie, an important commercial centre, and will have three double-track platforms, each 300 m. in length. The architect for this station, Baron V. Horta, has prepared plans for a six-storey building to be erected on the site. The basement and ground floor will be utilised by the railway, the four floors above being available for offices. The main entrance will be situated at the junction of the Rue de l'Impératrice and the Putterie, and will give direct access to the booking hall, which will contain a post office and shops. There will be a side entrance in the Cantersteen. A subway will be provided by means of which outgoing travellers will be able to reach an intermediate floor, from which stairs will give access to the platforms. The connection to this intermediate floor for arriving travellers will be by stairs or escalators. The exit will be situated in a new street, which is to be constructed solely for this service and will contain ample provision for the parking of motor cars. The station will also be in direct communication with the underground municipal motor garage, which is situated in the immediate neighbourhood. At a distance 800 m. north of the Central Station there will be another halt, at Congrès. The section of the tunnel between the south end and the Rue de l'Hôpital is now completed and the substructure of the station is well in hand.

(*d*) The building of a series of viaducts and retaining walls covering a total length of 216 m., and connecting the north end of the tunnel with the North Station. This work will also include the southern portion of the new station. Demolition and excavation for this portion of the new railway are in an advanced state.

(*e*) The complete rebuilding and the raising of the level of the North Station. The new structure will be situated farther north than the present building. The existing station, which was built in 1844, is illustrated in Fig. 5. This rebuilding work, which is in progress, is a complicated operation owing to the necessity of maintaining the train service during the whole period. An item in the work is illustrated in Fig. 6, on page 10, which shows the removal of a signal box over a distance of 25 m. This was carried out without putting the control discs out of service. The old concrete pillars on which the signal box was originally carried can be seen to the right of Fig. 6. The concrete base on which the signal box stands was jacked into its new position and is shown in the figure resting on piles. The work was carried out in ten days, a rate of 2½ m. a day.

(*To be continued.*)

THE PHYSICAL SOCIETY.—The report of the Council of the Physical Society, which has recently been issued shows that there were 1,084 honorary Fellows, Fellows, and student members on the roll of the Society on December 31, 1939, as compared with 1,052 on December 31, 1938.

DISCRIMINATIVE-OVERCURRENT AND EARTH-LEAKAGE PROTECTION FOR ELECTRICAL CIRCUITS.

ONE of the results of the interconnection of large power stations and the use of widespread distribution systems is that considerable amounts of energy are involved when a fault occurs. To ensure that the conditions that arise do not cause damage to the plant or the cessation of supply, a number of protective systems have been devised the object of which, as is well known, is to cut out the faulty section at the earliest possible moment without at the same time affecting the operation of the sound portions. One of the earliest and simplest means of doing this is by means of overcurrent and earth-leakage protection; and this system, owing to its simplicity, reliability and comparative economy, is probably still the most widely employed. Its principles may be illustrated by referring to the types of overcurrent and earth-leakage apparatus made by Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. These range from the direct-acting coils used in small switchgear to the modern current-transformer energised relays which are designed for operation with the largest circuit breakers.

Basically, a simple overcurrent equipment consists of three current transformers and a three-element relay. Excess current in any phase is reproduced in the secondary of the current transformer and hence in the relay. When a predetermined current value is reached, the contact of the relay are closed and the circuit breaker associated with it is tripped. Similarly, the secondaries of the current transformer are connected to an earth-leakage relay in such a way that no current flows so long as the sum of the phase currents is zero. If, however, an earth leak develops, this condition is not fulfilled and an out-of-balance current will flow in the relay coil, causing it to operate.

The relay now in most common use is of the induction type with an inverse and definite minimum time characteristic. The operating element consists of an eddy-current induction-disc motor which is arranged to operate in a time that varies inversely as the operating current down to a limiting value at which the delay becomes sensibly constant regardless of any further increase in current. This discriminating feature is embodied in the induction-disc motor, and the timing can be varied by altering the distance through which the disc rotates. The current setting is effected by tapping the operating coil, the taps being connected to a plug-setting board so that a 4 to 1 current range in seven tappings is obtained. With this system of protection, therefore, it is possible to adjust the breakers controlling the various sub-circuits so that in event of a fault they open in a predetermined sequence. This enables a general interruption of the supply on account of minor faults or local overloads to be avoided. For any value of current the time taken to operate will be proportional to the definite minimum time setting. For instance, the operating time with a definite minimum time setting of one second will always be half that with a definite minimum time setting of two seconds. The current scale of the relay is graduated in percentage of plug setting, so that, for a 200/5 ampere current transformer operating with a relay on a 125 per cent. plug setting, the primary current corresponding to the 400 per cent. value is $\frac{400}{100} \times \frac{125}{100} \times 200$ amperes = 1,000 amperes, and the corresponding time of operation is 2·5 seconds at the two-second definite minimum time setting.

1·25 seconds at the one-second definite minimum time setting, and so on, for the other settings. For overloads in excess of approximately 650 per cent. of the full-load current—as, for example, a short-circuit—the relays will operate in definite sequence in 0·5 second, 1·0 second, 1·6 second and 2 seconds, respectively. Positive time discrimination is thus secured, so that the circuit breaker nearest to the fault will open before any of the others are affected.

The correct design of the current transformers used in connection with overcurrent and earth-leakage relays, especially the latter, is important. Most standard 15 volt-ampere, Class C transformers are suitable, but where bushing or through-type transformers with only one primary conductor are used for currents of less than 1,000 amperes, care must be taken to ensure sufficient secondary overload capacity to bring the overcurrent relay to its definite minimum time. When such current transformers have to operate in conjunction with an earth-leakage relay, it is desirable that they should be accurately balanced, and have no other secondary burden to upset this balance. Similar precautions are necessary when low-ratio wound-type current transformers, designed for maximum fault currents exceeding about fifteen times their normal rating, are used.

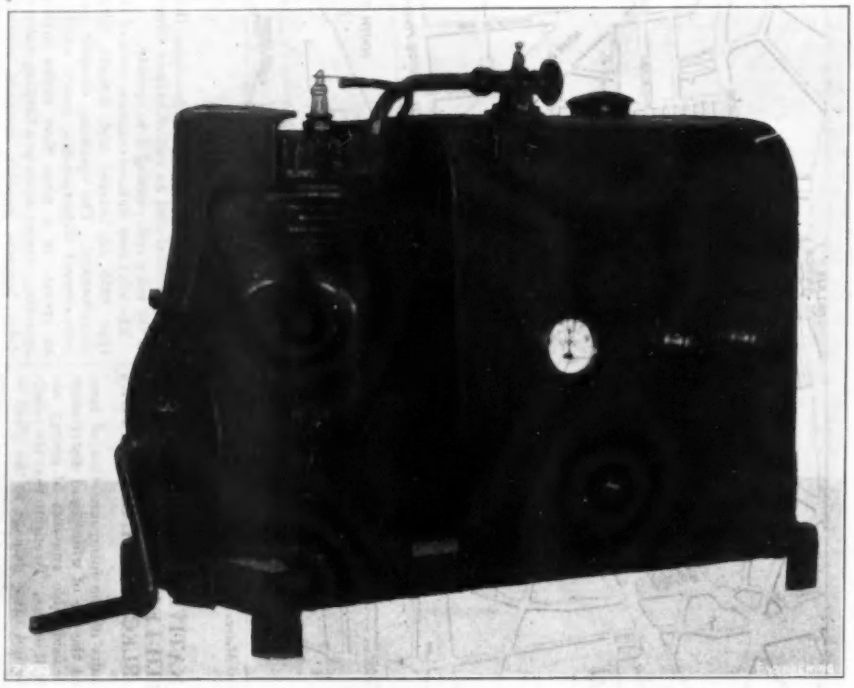
The main applications of the relays that have just been described are the protection of generators, bus bars, transformers, overhead and underground feeders and motors. The simple over-current group described above is applicable to all five cases. The relay must be set to operate at a current in excess of the normal full load of the apparatus protected and the timing adjusted in relation to that of the associated gear. Instruments can be connected in series with the relay when average current transformers are used without detriment to the protection. It is claimed that the three-wire earth-leakage arrangement, which has also been described above, is an effective means of rapidly isolating an internal earth-fault within a power transformer. A definite minimum time setting of the order of 0·2 second to 0·5 second ensures stability against current-transformer errors due to switching surges and heavy through fault currents. A relay current of 10 per cent. can generally be used with complete stability. This class of protection can also be employed for earth-fault protection on feeders and is generally adopted on industrial gear, such as the sensitive earth-leakage protection of cables in mines, where settings as low as 5 per cent. of normal full load can be obtained. This arrangement can also be applied to the protection of motors, but in this case it is more usual to employ restricted earth-leakage protection. As an alternative to three-line current transformers, a single-core balance current transformer embracing all three phases can be used, but the results obtained are the same in both cases.

Combined overcurrent and earth-leakage protection is, however, the most popular system. It affords, it is claimed, full protection with only three current transformers and a minimum of three relay elements, which can be housed in one case. It can be used successfully in connection with transformers, feeders and motors to give protection equivalent to that provided by the systems already described, if average current transformers are used. Restricted earth-leakage protection is one of the best forms of earth-fault protection for a transformer or generator winding when either star-connected with an earthed neutral or delta-connected and using an inter-star earthing transformer. Protection is restricted to the windings and immediate connections and the leakage relay only operates when a fault occurs in this zone. In the interests of stability it is generally desirable to use the four associated current transformers which make up the system for no other purpose than earth-leakage protection. With average current transformers, a relay setting of 10 per cent. can be used and a definite minimum time of 0·2 second is recommended. Restricted earth-leakage protection can be applied to four-wire distribution systems. Here, also, the earth-leakage relays operate only in the event of an internal fault and are immune from all other conditions of unbalance. Once again a relay setting of 10 per cent. and a definite minimum time of 0·2 second can be used. The system can be extended by using back-up earth-leakage protection to perform one or several of a variety of functions. For instance, it can be employed to provide a back-up to the restricted earth-leakage group. The setting, however, must not be below that of the connected apparatus, from 1 second to 2 seconds being usual. When a neutral earthing resistance is used the relay can be set with relation to the thermal rating of the resistance.

UNITED STATES COLLIERY INDUSTRY.—The output of bituminous coal from collieries in the United States, during the week ending June 15, totalled 1,333,000 tons, compared with 1,345,000 tons in the preceding week and 1,067,000 tons in the corresponding week of 1939.

300-WATT PORTABLE ELECTRIC GENERATING SET.

MESSRS. BRADBY'S ENGINEERING WORKS, LIMITED, LONDON.



300-WATT PORTABLE ELECTRIC GENERATING SET.

ON page 25 of our previous volume we described a portable electric generating or pumping plant manufactured at the Ditchling works, Sussex, of Messrs. Bradby's Engineering Works, Limited, 41, Rylett-crescent, Shepherd's Bush, London, W.12. This set is made with an output of 360 watts at 12/15 volts, or 400 watts at 24 volts or 32 volts. In order to meet a demand for a portable lighting set, the firm has now developed the unit shown in the accompanying illustration, and having an output of from 200 watts to 300 watts of direct current at 110 volts. As will be recognised, the unit consists of a single-cylinder petrol engine coupled directly to a dynamo, both being carried on the same angle-iron base. The dynamo is masked, however, by a casing, the upper part of which is formed as a petrol tank. This tank has a capacity sufficient to enable the set to run continuously for from 12 hours to 14 hours at one filling, the fuel consumption at full load being 0·67 pint per hour. The engine develops 1½ h.p. when running at 2,500 r.p.m., and is of the four-stroke cycle type. The cylinder is of 2 in. bore by 2 in. stroke, and the capacity is 104 c.c.

The cylinder head and piston are of light alloy and a standard 14-mm. sparking plug is fitted. The cylinder is finned and is air-cooled by means of a fan combined with a heavy flywheel, the air stream being directed over the fins by effective cowling. A crankcase breather directs air on to the valve stems. Ignition is by a Wico magneto, which is chain-driven at crankshaft speed. The carburettor is of the suction type, and has an adjustable throttle and choke, the former enabling the engine speed to be controlled up to its maximum of 2,500 r.p.m. Starting is by a crank handle. The crankshaft is mounted in ball bearings, as also is the dynamo spindle. All parts are splash-lubricated, and the oil-level in the sump can be ascertained by means of a graduated dip-stick attached to the filler plug. It is stated that the consumption of lubricating oil is negligible. This generating set, which is distinguished from the one previously described by the name "Bradham," is intended to meet the lighting and other requirements of small houses, air-raid shelters and other buildings in districts where current is not available from the mains, and is also likely to be of use as an emergency stand-by set, in case of mains failure, for hospitals, etc., in which interruption of current might have serious results. It is self-contained, requires no batteries, and can be connected directly to the lighting circuit. An ammeter and terminals are mounted on the dynamo casing.

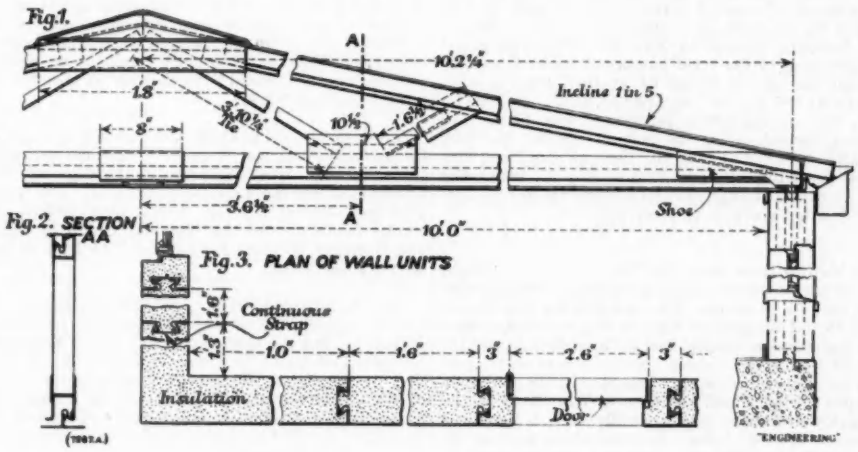
STEAM-ENGINE EXPORT GROUP.—Mr. I. V. Robinson, 36, Kingsway, London, W.C.2, is chairman and secretary of the Steam Engine Export Group.

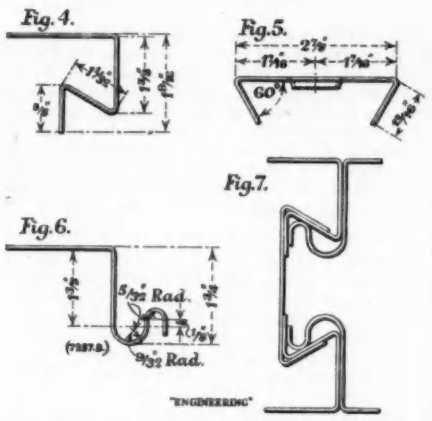
THE G.B. SYSTEM OF SHEET-STEEL BUILDING.

AN interesting example of the application of steel to building construction is afforded by the G.B. system, which has been designed by Mr. G. Bacher, 178, Charing Cross-road, London, W.C.2. It is claimed for this system, which has been evolved over a number of years as a new method of building construction, and is not simply a war-time substitute, that it is easy and rapid to erect and dismantle. These conditions are assisted by the fact that a minimum of foundations are required. It is claimed to be wind and weatherproof, and the use of insulating material between the outer and inner walls renders it proof against sudden changes of temperature, eliminates condensation and overcomes resonance. It is economical to keep clean and is unlikely to be subject to damage by lightning. Temporarily outweighing these advantages at the present time is, of course, the difficulty of obtaining the necessary material. As, however, for the time being, the system will be principally used for the construction of camps, hutments and other buildings under government control, this can, perhaps, be overcome where necessary.

The details of the G.B. system are shown in the illustrations on the opposite page. The foundation may consist of a rough concrete raft about 6 in. deep levelled off with a finer mixture in the usual way to a depth of 3 in. This upper surface is trimmed round the sides and is finally coated with anti-damp solution. Alternatively, tongued and grooved wooden flooring laid on wood joists can be used, though this is hardly likely to be practicable at the present time. The walls, both exterior and interior, the ceiling, roof, roof trusses and the door and window frames are all constructed of No. 18 gauge bright cold-reduced steel plates, which are flattened by a patented process and fabricated by jigs into interlocking sections. All the parts are dipped in a bath of chromate paint before leaving the factory. This paint is a special anti-rust solution which has been developed and tested at Farnborough and has stood up to severe tests by salt spraying. As shown in Figs. 4 and 6, the surface sheets are of two types, "closed" and "open." A length of 3 in. at each end of the "closed" sheets is bent at right angles and the final 1½ in. of the angle thus formed is again bent at angles of 60 deg. so as to form a rough Z shape, as will be clear from Fig. 4. Similarly, a length of 3 in. at each end of the "open" sheets is bent at right angles and the last bend is formed into a double U with radii of $\frac{1}{32}$ in. and $\frac{1}{16}$ in., respectively, as indicated in Fig. 6. These sheets, which are either 8 ft. or 3 ft. 6 in. long, are then interlocked as shown in Fig. 7, to form a double wall with an intervening cavity of 4½ in. The elements of this double wall are held in position by nearly full length clamping elements, described as wall clamps. These wall clamps, shown in section in Fig. 5, are 7 ft. 9 in. or 3 ft. 4 in. long, and are made from

G.B. SYSTEM OF SHEET-STEEL BUILDINGS.





4½-in. wide strips, a part ¾ in. wide being bent over at each side at an angle of 60 deg.

The appearance of the complete assembly with the clamps in position is illustrated in Fig. 3, which shows a standard wall joint. The system adopted for assembling a wall is shown on the right in Fig. 1, from which it will be seen that for the external walls, steel floor or skirting channels and apron pieces of special shape are laid on the foundation concrete, which has been previously treated with Bitumastic compound. The outer and inner wall sheets are automatically spaced from each other by these aprons, the skirting channels and the wall clamps, while the space between them is filled with any locally available dry insulating material such as slag, sand, straw, bracken or sawdust. It is stated that this material need not be absolutely dry before being placed in position as any initial moisture will be driven out by the heat of the sun on the outer wall, or by the warmth from inside the building. In other words, the cavities between the walls act as drying kilns. It is further claimed that even in London no trace of condensation has appeared, while experience with large insulated sheet-steel schools and hospitals in France shows that buildings of this kind are cool in summer and warm in winter, the cost of heating hospitals being about 30 per cent. less than that of corresponding brick buildings.

The door and window frames, which are usually constructed as "closed" units, interlock with the adjoining wall members. The windows are of standard steel casement construction. The door frames are provided with welded hinges from which the standard wooden doors are hung. The walls are finished off at the top by ceiling channels and gutter aprons, the former being virtually skirting channels placed upside down. These channels cap the walls and also form picture rails, while the gutter aprons are utilised for the attachment of the gutters proper, as shown in Fig. 1.

The ceiling and roof sheets are of the same shape as those used for the walls, but are 10 ft. long. They are carried by light trusses, shown in Fig. 1, which are built up from No. 18 gauge sheet steel members. These members are welded together at the works and are sent out ready for erection. The struts and ties of the trusses are shaped to enable ceiling sheets of first the "closed" and then the "open" types to be hung on to and interlocked with the ties; and the roof sheets of first the "open" and then the "closed" types to be laid in the recesses in the struts, as shown in Fig. 2. To assemble a roof, the trusses, which only weigh 70 lb., are placed 18 in. apart on top of the walls and are held firmly in position by a baseplate projection, which fits into the recess between the ceiling channel and the gutter apron. At the same time, the ceiling sheets are interlocked with the ties and are pushed back towards the truss baseplate. This leaves a 3-in. space in the centre of the hut, which is filled by a 3-in. ceiling centre strip. If desired, the trusses can be placed farther apart. Sheet-steel purlins and ceiling joists or carriers would then be used, so that the roof sheets would rest on the purlins and the ceiling sheets would hang on sheet-metal hooks suspended from the ceiling carriers.

Insulating material, to a thickness of 4½ in., is next spread over the ceiling, and the gutters, which also locate the ends of the roof sheets, are hung over the gutter aprons. After this the roof sheets, first those of the "open" and then those of the "closed" type, are placed in position, so that their interlocked ends rest inside the strut channels. One or more of the ceiling sheets are provided with trap doors, to give access to the loft. The last roof and ceiling sheets form the gable end. They are clipped together from the inside, where they overhang the walls and are interlocked at the centre by a channel clamp. Finally, the ridge cap is placed in position, and, if desired, the centre of each roof sheet can be clipped to it.

The interlocking joints are mechanically water and infiltration proof, the use of mastics not being necessary. Any drip water passing through the outer joint is caught in the first bend of the interlocking return of the "open" sheet. Roof drip is thus discharged into the gutter and wall drip through slots, which are cut every 18 in. in the apron, so that both pass through pipes in the foundation into the ground. Light partitions, constructed similarly to those used for the walls, can be interlocked with or attached to the main walls. The latter method is used when it is desired to sub-divide a large room after the original building has been completed. In the case of a partition extending across the building, and attached at each end to the main walls, assembly and erection would be effected by placing the four corner pieces in position and drilling and tapping the ceiling and skirting channels to take the fixing bolts or screws. Two of the corner pieces on the same side of the partition would then be fixed and the partition floor channel inclined against them. The other end of the partition would be supported on trestles, assembled, filled, capped and pushed upright against the fixed corner pieces. Finally, the other two corner pieces would be screwed or bolted to the floor and ceiling channels. The partitions, once interlocked, are, it is claimed, extremely rigid, although they are usually only 2¼ in. thick.

The erection of a particular building is carried out to a plan provided by the makers, and, it is claimed, that one fitter and three labourers can complete an army hut roughly 60 ft. by 20 ft. by 8 ft. inside dimensions within 60 man-hours. Conversion into a bungalow would take another 30 to 40 man-hours. No fitting or cutting on the site is necessary, and all the parts easily interlock together, owing to the comparatively large surfaces involved. All the surfaces of buildings, inside and out, are smooth and the joints give an attractive panelling effect. The inside walls can be painted or papered. If painted, they are, of course, washable, and the life of the structure can be made as long as that of any other building by maintaining the surfaces. Individual outer wall sheets can be removed and replaced, without the necessity for interfering with the inner wall sheets, should repairs be necessary. All the roof sheets and gutters can be dismantled without disturbing any of the ceiling sheets. An important claim for the G.B. system is that a whole building can be added to, or taken down and re-erected elsewhere, quite easily, either in its original form or on a symmetrical plan. Alternatively, the elements can be used to erect an entirely new building. For this purpose, a four- or five-room bungalow can be loaded on to two lorries. As, in the national interest, it is necessary, at the present time, to economise in the use of steel, designs have been prepared in which over 90 per cent. of the steel sheeting is replaced by asbestos-cement sheet, ¼ in. thick, which will interlock in the same manner as the steel sheets. In addition, asbestos-cement sheets will interlock with all the standard steel units. A 90-per cent. asbestos-cement sheet building would be about 15 per cent. to 20 per cent. heavier than one of steel, but would, it is stated, be just as transportable and easy to erect and dismantle.

It may be mentioned, in conclusion, that a bungalow has been erected on this system by Messrs. E. Pollard and Company, Limited, St. John-street, London, E.C.1, in the Newton-street car park behind the Holborn Restaurant, Kingsway, London, W.C.2.

GRINDING-ACTION THEORIES.

THE principles underlying the cutting of metals either by rotating the work against a rigidly-held tool, as in turning, or traversing the tool over the stationary work, as in shaping and slotting, have been investigated, among other methods of approach, by the study of the chips formed, typical examples of such investigations being found in the various reports of the Cutting Tool Research Committee of the Institution of Mechanical Engineers. Since the grinding wheel consists, essentially, of a multiplicity of abrasive grains forming cutting tools, although unlike turning or shaping both work and tool have motion, it is logical to approach any theory of grinding from the standpoint of the geometry of chip formation. An interesting review of grinding theories is contained in a paper by Mr. Albert H. Dall, of the Research Department of Messrs. The Cincinnati Milling Machine Company, Cincinnati Grinders Incorporated, and this review has been published in the April issue of the *Journal of Modern Production Practice*, published by Messrs. Charles Churchill and Company, Limited, Coventry-road, South Yardley, Birmingham. A brief summary of Mr. Dall's paper is given below.

The paper commences with a short survey of grinding-wheel structure. Natural stone wheels, which have only a limited field of application, are excluded, the discussion being limited to the synthetic wheel, consisting of the abrasive particles and the bonding material which holds these particles or grains together. In general, the bonding material does not completely fill the interstices between the particles but merely covers them, the actual bond consisting of the fusion of this coating between grain and grain, at a number of points. There are, in consequence, interspaces between the bonded grains, and the rigidity of the connection depends on the amount of bonding material and also upon the distance between the grains. Although abrasives are sold under a wide variety of trade-names, abrasives may be classified, speaking generally, into two types, as regards metal cutting, viz., aluminium oxide (Al_2O_3) and silicon carbide (SiC). Emery and corundum are forms of aluminium oxide found in nature with varying degrees of impurity, but aluminium oxides are also produced by means of an electric furnace. The silicon carbon group is invariably produced in the electric furnace, and it is to these manufactured abrasives that the various trade-names are applied. Pure silicon carbide has a hardness of about 9·5 on the Moh scale, aluminium oxide having a hardness of about 9·0 on the same scale on which scale the hardness of diamond has a value of 10·0, while cementite (FeC_3) is below 7·0. Correlating these values with those commonly used in engineering, it may be here noted that the Moh. 7·0 is equivalent to a Brinell hardness, with standard ball, of 444; a Vickers diamond pyramid hardness of 474; and a Scleroscope hardness of 64.

All the abrasives break with the conchoidal or crystalline fracture that is necessary for effective cutting, or with a combination of the two. All are crushed to give the different degrees of coarseness or fineness of cut required in practice, the crushed material being usually sieved to grade the grains. The grain size is, perhaps, the most nearly universally accepted characteristic of grinding wheels, and is derived from the spacing of the sieve wires. Thus, a 60 grit must pass through a sieve having 60 wires per lineal inch. The coarsest grain usually employed is No. 4, and from this size to No. 240, the grains are graduated by a sieve either of wire or silk; the latter is used in flour milling. Finer material than this, designated "flour sizes" is graded by flotation in liquid. On the character of the fracture of the grains largely depends the cutting efficiency of the wheel, but its durability, in the main, is a function of the bonding material. The bonding material has, of course, to be strong enough to hold the abrasive

grains in place in a rigid manner, analogous to that effected by a tool-holder, and to resist, with an adequate factor of safety, the centrifugal forces resulting from high speeds. It has, moreover, to possess a tensile strength appropriate to the work it has to do, and on this property depends the "hardness" or "softness" of the wheel. This term "hardness" is not to be confused with the hardness of the individual grains referred to earlier, but denotes the grade of hardness or strength of bond of the whole wheel. Thus, the bond may be so strong in a very hard wheel as to retain the abrasive grains long after they have become dulled, with consequent inefficient cutting, or may be so weak in a very soft wheel that the grains are pulled out of the wheel before they have done anything like the work they are capable of, this condition, again, resulting in inefficient cutting.

(To be continued.)

DRAFT SPECIFICATION OF ENGINEERS' PRECISION LEVELS.

A DRAFT specification of the series of engineers' precision tools has now been issued for bubble-type levels for use in engineering workshops. The draft has been prepared by the Technical Committee M.E./59, Measuring Tools, of the British Standards Institution, and is now being circulated for technical comment before acceptance as a British Standard. The draft specification is entitled "C.F. (M.E.) 6289 Draft B.S. for Precision Levels for Engineering Workshops," and any person or organisation able to make constructive criticism of it may obtain a copy on application to the British Standards Institution, 28, Victoria-street, London, S.W.1. The latest date for sending in any comments on the specification is August 24, next.

The application of precision bubble-type levels having become more general in workshop practice, the specification has been drawn up with the object of recommending general features and degrees of accuracy for three patterns of such levels. These can be used not only for general levelling and verticalising purposes in connection with the assembly and installation of machine tools, but also for testing the flatness of surfaces by the method outlined in Appendix B of B.S. 817, Cast Iron Surface Plates and Tables. Of the three recommended patterns of level, type 1 is a block level about 8 in. long, with a continuous hardened and lapped base of steel on which slip gauges may be wrung. Type 2 is a block level with a cast iron or brass base formed with pads at the two ends, the centre being relieved. The pads may be either flat transversely or finished with a longitudinal Vee-groove for use on cylindrical surfaces. The length of base may be 9 in., 12 in. or 18 in. Type 3 is a block level of cast iron about 8 in. square. All the faces may be flat transversely or, alternatively, the base and one vertical face may be formed with a longitudinal Vee-groove.

The scale is recommended to be in $\frac{1}{10}$-in. divisions, a sketch of the style of graduation being given. It is suggested that, for workshop and inspection room practice, the degree of sensitivity be in terms of a base length of 10 in.; thus, 0·001 in. per 10 in. is equivalent to a sensitivity of 1 in 10,000. Since 1 second of arc is very closely equal to an inclination of 5 in 1,000,000, a level with a sensitivity of 0·001 in. per 10 in. is very closely equivalent to a 20 second bubble. The recommended sensitivity for type 1 level is 0·00025 in. per 10 in. (5 seconds), or 0·0005 in. per 10 in. (10 seconds). For type 2, the sensitivity may be either 0·0005 in. per 10 in., or 0·001 in. per 10 in. (20 seconds). Type 3 may be either 0·0005 in. per 10 in., or 0·001 in. per 10 in. Each level shall have a means of adjustment such that when it is placed on a truly horizontal surface the two ends of the bubble will give equal readings on the scale to within 0·1 division. At the standard reference temperature of 68 deg. F., the length of the bubble shall be equal to the distance between the centre lines of the scales to within 0·5 division.

The base of each level is to have the sensitivity marked on it in the terms described above. When tested on a tilting table, readings being taken at each division at each end of the bubble, each level shall comply with the following limits of error: (1) The average sensitivity (*i.e.*, the average value of one division) shall not differ from the value marked on the level by more than $\pm$ 10 per cent. (2) The maximum deviation of the value of any one division from the average value shall not exceed 0·1 division. The base of Type 1, level shall be flat to within $\pm$ 0·00005 in.; of Type 2, within $\pm$0·0002 in.; and of Type 3, within $\pm$0·0001 in.

The specification also makes suggestions as to fingerholds, finishing, packing and marking and, in an appendix, furnishes some notes on the selection of sensitivity of a level, and on the choice of materials and mounting, the latter particularly with regard to the desirability of avoiding expansion and other strains in the glass tube.

LABOUR NOTES.

ACCORDING to *The Ministry of Labour Gazette*, the number of insured persons between the ages of 16 and 64, recorded as unemployed in Great Britain and Northern Ireland at May 20, 1940, represented 6·1 per cent. of the total number of insured persons, between the ages of 16 and 64, at July, 1939, as compared with 6·7 per cent. at April 15, 1940. At May 15, 1939, the corresponding percentage was 10·2. For persons insured under the general scheme, the percentages were 6·2 at May 20, 1940, as compared with 6·8 at April 15, 1940, and 10·5 at May 15, 1939. For persons within the agricultural scheme, the percentages were 3·4, 4·4 and 5·8, respectively.

At May 20 there were 730,773 persons on the registers of Employment Exchanges in Great Britain who were out of a situation. This was 109,254 less than at April 15 and 503,228 less than at May 15, 1939. There were registered as unemployed in Great Britain 102,730 persons who were on short time or otherwise temporarily suspended from work. This was 12,548 more than at April 15, but 95,887 less than at May 15, 1939. Of unemployed persons who normally seek a livelihood by means of jobs of short duration, there were on the registers 47,319. This was 4,833 more than at April 15, but 12,345 less than at May 15, 1939. The total of 880,822 persons on the registers included 742,204 applicants for unemployment benefit or allowances and 138,618 non-claimants.

In the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in May are estimated to have resulted in an increase of about 115,000*l.* in the weekly full-time wages of nearly 1,000,000 workpeople and in a decrease of nearly 10,000*l.* in those of nearly 300,000 workpeople. The workpeople whose rates of wages were reduced had received increases of greater amount earlier in the year. The principal groups of workpeople whose wages were increased included coal miners in Northumberland, South Derbyshire, Nottinghamshire, Leicestershire, Cannock Chase and Scotland, women and girls employed in engineering establishments, pottery workers and workpeople employed in the textile bleaching, dyeing, printing and finishing industry.

Other groups of workers whose wages were increased included those employed in the rubber industry and in milk distribution in England and Wales. The decreases affected mainly coal miners in Yorkshire, North Derbyshire, North Staffordshire and Warwickshire, and workpeople employed in steel-melting shops and iron and steel rolling mills. The changes, so far reported, in the five completed months of 1940, in the industries for which statistics are available, are estimated to have resulted in a net increase of about 1,170,000*l.* in the weekly full-time wages of about 6,250,000 workpeople.

The number of trade disputes involving stoppages of work, reported to the Department as beginning in May, was 92. In addition, 13 disputes which began before May were still in progress at the beginning of that month. The approximate number of workpeople involved in these 105 disputes, including workpeople thrown out of work at the establishments where the disputes occurred, was 36,000, and the aggregate duration of the disputes in May was about 91,000 working days.

At June 1, the official cost-of-living index-figure was 81 per cent. above the level of July, 1914, as compared with 80 per cent. at May 1. The rise of one point was due to increases in the prices of coal and of clothing. For food alone, the index figure at June 1 was 58 per cent. above the level of July, 1914, as compared with 59 per cent. at May 1, the decline being accounted for mainly by reductions in the prices of milk and cheese.

Replying to a question in the House of Commons last week, Mr. Bevin, the Minister of Labour and National Service, stated that the number of civilians in training at the Government training centres was now about 10,700. This was a record. It was nearly 1,000 more than a week ago and nearly 2,000 more than a fortnight ago. In the last four weeks more than 6,000 men had been sent forward to training centres. This was also a record, but they needed many thousands more. Those awaiting entry into training would be quickly absorbed, and a continuous flow of applicants would be needed to keep the centre at full strength and to fill the new places which were being provided. Shift working was being introduced and new centres were being established, and greatly increased numbers, both of men for training and of instructors, were required.

The shortage of fully-qualified instructors was at present, Mr. Bevin said, the most serious factor limiting the increase in the numbers in training. He hoped that any fully-skilled fitters, machine operators and instrument makers who were not only highly-skilled craftsmen but could also impart their knowledge to others and were not at present employed on work of vital importance, would come forward at once for this most important work.

It was mentioned in these Notes a week ago that the General and Municipal Workers' Union had decided to place 250,000*l.*, free of interest, at the disposal of the Government for the duration of the war. The Transport and General Workers' Union have arrived at a similar decision, and the National Union of Tailors and Garment Workers have decided to lend 10,000*l.* on the same terms.

The Confederation of Shipbuilding and Engineering Unions has applied to the Shipbuilding Employers' Federation and the Engineering and Allied Employers' National Federation for a wage increase of 10*s.* a week. The Amalgamated Engineering Union is not a unit of the Confederation, but at its recent meeting, the organisation's National Committee instructed the Executive Council to apply to the employers for an advance of 3*d.* an hour.

At a meeting in London last week of the Joint Consultative Committee of representatives of the General Council of the Trades Union Congress and of the British Employers' Confederation, draft reports were considered relating to the proposed national arbitration machinery to deal with wage rates, the strengthening of the fair wages clause, the restoration of trade union conditions after the war, and hours of work including schemes for the relief of shift workers engaged on intensified production in munition factories. No final decision was reached.

Mr. Peake, Under-Secretary, Home Office, stated in the House of Commons last week that the Government had given consideration to the question of proceeding with the further stages of the Workmen's Compensation Bill, which had received a Second Reading on April 30, before the war entered upon its present phase and before the formation of the present Government. The Bill had not received the general approval of the House, and many hon. members had voted in support of a reserved amendment. It was obviously most undesirable that there should be acute division and possibly acrimonious debate, in relation to any measure brought forward by the Government at the present time, and the Government had, therefore, made some inquiries with a view to estimating the prospects of arriving at some accommodation in the matter.

These preliminary inquiries, Mr. Peake went on to say, had led the Government to the view that it was desirable for the time being to suspend progress with the Bill pending the result of further discussions. The intention had been to bring the measure into operation on July 1, and it was regretted that some disappointment must be inevitable at the Government's decision. The Government would, however, proceed at once to consult with the representatives of industry whose views had been obtained before the Bill was introduced and would also be glad to receive informal representations coming from any quarter of the House.

A Bill introduced by the Minister of Labour and National Service proposes to increase unemployment benefits and contributions and to bring within the scope of the unemployment and assistance schemes "black-coated" workers earning up to 420*l.* a year. The weekly rate of benefit under the general scheme is to be raised by 3*s.* for men and women—that is, for persons of the age of 21 and upwards. For young men and women between the ages of 18 and 20 the weekly rate will be raised by 2*s.* The present men's rate of 17*s.* will become 1*l.* and the women's rate of 15*s.*, 18*s.* Young men will get 16*s.* instead of 14*s.*, and young women 14*s.* instead of 12*s.* It is not proposed to raise the rates in respect of boys and girls. At present, benefit is payable only in respect of continuous periods of unemployment and no continuous period may be less than three days. The Bill proposes that benefit shall be payable if a man is unemployed for a minimum of two days out of any six consecutive days.

To meet the increased cost of the changes, it is proposed to raise weekly rates of contribution under the general scheme by a penny for men, women, young men and young women in respect of each of the three parties involved, namely, employer, worker and Exchequer.

A COAL-CLEANING POLICY.*

By ARTHUR A. HIRST, D.Sc., F.Inst.P.

ON April 5 last, the Mines Department announced the formation of a Coal Production Council to deal with the problem of increasing the annual output of coal in order to increase exports and to maintain adequate home supplies. It is desirable that increased production should not be obtained at the expense of the quality of the fuel, and that pre-war standards of preparation should be at least maintained, and preferably improved. As regards the export market, British coals enjoy a high reputation, but this will be maintained or enhanced only if they are sized and cleaned to suit the requirements of foreign consumers. Careful preparation of exported coal will help, not only in creating export trade, but in ensuring its continuance after the war. For the internal market, high-grade fuel should be available to those sections of industry to which such fuel is of real advantage, lower grades being utilised for purposes where quality is of less importance. It is specially desirable that, as far as possible, low-ash coal should be used for the production of metallurgical coke. In the 1914-18 war, the high-ash coke then made greatly increased the fuel consumption per ton of pig iron and materially reduced the output per blast furnace.

At the present time there is an abundant demand for British coal, and in such circumstances the natural tendency is to relax rather than to improve standards of separation; but, unless this tendency is resisted, our coal resources will not be utilised to the best advantage and foreign buyers are unlikely to become satisfied customers. There are now relatively few collieries which do not possess cleaning plants of fairly modern design, and individual producers can do a great deal by ensuring that their own plants are efficiently operated. Official encouragement may be desirable to secure uniform action in this respect. In existing circumstances, however, there are special difficulties in the way of maintaining high standards. In the drive for increased output, many preparation plants will be overloaded, and it may be impossible to obtain a high-grade clean coal without losing coal and/or middlings in the refuse product; but costly alterations to, or replacements of, cleaning plants are scarcely feasible or desirable at the present time. In developing the policy now submitted, the intention has been to find the easiest ways of achieving the objects of coal-cleaning, using as far as possible existing separating plant, alterations where necessary being confined to extensions to present apparatus.

Broadly speaking, the ultimate objects of coal cleaning are:—(*a*) to reject, with the minimum loss of combustible material, the fraction of the raw coal which is totally or nearly incombustible, and to prepare the combustible material into such grades as can be used most advantageously. An investigation of ways of achieving these objects entails a consideration of:—(1) the nature of coal with respect to washability; (2) the characteristics of coal-cleaning machines; and (3) the grades of coal required.

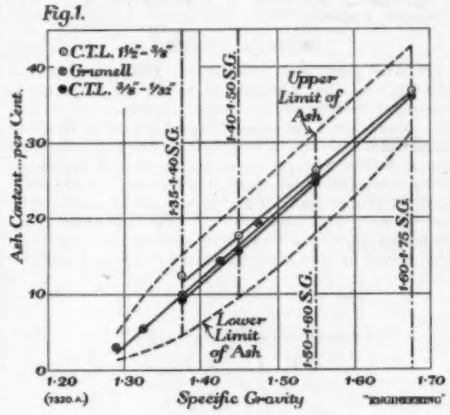
In some cases, moderate crushing will release high- and low-ash particles from the middlings; in others, the middlings are so finely intergrown that reasonable crushing does not produce this result. Roughly speaking, there is a direct linear relationship between the specific gravity and the ash content of the particles of a particular raw coal. Fig. 1, on this page, illustrates such average relationships for a number of British bituminous coals, mostly from Midland collieries, examined in the Coal Treatment Laboratory, Birmingham University. Grumell's† average figures, plotted on the same graph, are in excellent agreement. It will usually be found that, for the same specific gravity, larger particles have a higher ash than smaller ones. The rather wide spacing of the curves showing roughly the upper and lower limits of ash content indicates that the average relationship must be used with discretion.

While there is a rough consistency in the ash contents of the various specific-gravity fractions in British coals, the relative proportions in which such fractions occur vary considerably. The difficulty of separating a given coal is usually assessed on the basis of the proportion of middlings present or, more exactly, according to the proportion of material with a specific gravity approaching that of the desired separation. If, for example, a separation of 1·45 sp. gr. is required and there are 20 per cent. to 40 per cent. of 1·40 sp. gr. to 1·50 sp. gr. floats in the raw coal, separation will be difficult.

In common practice, a coal-cleaning plant produces two main products: clean coal and refuse. In the last few years, attention has been directed to the possibility of preparing pure coal, boiler fuel, and refuse. The preparation of a pure coal, together with a boiler fuel which will command a ready sale, may involve a cleaning problem which, if interpreted solely in terms of separation with respect to specific gravity, would be exceedingly difficult. However, the separation of raw coal into specific-gravity fractions is not the ultimate object of coal cleaning, and, if pure coal and saleable boiler fuel can be obtained by simpler means, it may be policy to adopt such alternatives.

For the present purpose, coal-cleaning processes may be divided into the three classes of dense-medium separators, jig and trough washers and similar machines, and pneumatic separators. Processes depending on variations in coefficients of friction or of resiliency are outside the scope of the paper. Table I, below,

Fig. 1.



shows the merits and demerits of the three classes of separator.

To achieve the objects of coal cleaning in the easiest way, it is necessary to recognise the imperfections as well as the merits of the various processes of separation

TABLE I.—*Characteristics of Coal-Cleaning Processes.*

Class of Separator.	Merits.	Demerits.
Dense-medium ..	Separation more accurate than for other types. Readily adapted to treat largest sizes.	Clean coal is wetted. Separate system required for finest sizes. Suspension medium must be provided.
Jigs, troughs, etc.	Separation fairly accurate. Same system will treat sizes from house cobbles to zero.	Clean coal is wetted. Separation less accurate than for dense-medium type.
Pneumatic ..	Clean coal is kept dry	Raw coal must be substantially free from surface moisture. Separation less accurate than for other types. Upper size limit that can be treated is smaller than for the other types.

and to arrange their application in accordance with one or more of the three following principles:—(1) to avoid the operation of the process under the conditions in which it is inefficient, or (2) so that the imperfections affect the cleaning results in the least harmful manner; (3) the innate characteristics of the process, of which the inefficiency is a result, may be used to advantage.

Under 2 Per Cent. Ash: "Pure" Coal.—As a general rule, this grade will not be used as a fuel, but rather as a raw material by the manufacturers of low-ash coke or smokeless fuel, for hydrogenation and for the possible production of colloidal fuel, and in various smaller fields.

Under 8 Per Cent. Ash: "Normal" Clean Coal.—For carbonisation, the ash content should be as low as possible. For boiler fuel, low-ash is less important. Nevertheless, it is a matter of experience that in normal times a boiler fuel with over 8 per cent. of ash does not sell readily, and in a competitive market it is much preferable that the ash content should not exceed 7 per cent. Coals with an ash content much above 7 per cent. will usually command a considerably lower price than coals having an ash content below this limit. In this grade of coal, free shale is objectionable in nut sizes, but less so in fines.

12 to 15 Per Cent. Ash: Medium-Ash Boiler Fuel.—Suitable for steam raising. Will bear only low transport cost, as the competitive price realised will be relatively low. Such fuel is suitable for most colliery boilers.

25 to 35 Per Cent. Ash: Low-Grade Fuel.—Can be burnt with reasonable efficiency under suitable boilers. Can carry scarcely any transport costs. The obvious outlet for this grade is for steam-raising at the colliery. However, few colliery boilers are capable of raising sufficient steam on such fuel. Moreover, in few British coals is the proportion of low-grade fuel—present as a specific gravity fraction in the sizes usually cleaned—adequate for mine consumption. Most collieries in this country will find it preferable to burn 25 per cent. to 35 per cent. ash fuel with an admixture of lower-ash coal.

To arrange the application of coal-cleaning processes so that their inefficiencies shall affect the cleaning in the least harmful way, it is desirable to consider the effect of impurities on various grades of coal. Table II, herewith, shows how the ash content of various grades of coal is affected by the presence of 2, 5 and 10 per cent. sinks with ash contents of 30 or 60 per cent. Sinks with 30 per cent. ash correspond to middlings of approximately 1·6 sp. gr., whereas for heavier sinks, such as flat shale, an ash content of 60 per cent. is about average. Figures are also included for the effect of 2 per cent. of sinks with ash contents of 10 per cent. and 15 per cent. on grades of coal with 1·5 and 2 per cent. ash. Material just sinking at 1·40 sp. gr. usually has an ash content between 10 and 15 per cent.

From Table II it is evident that the harmful effect of impurities varies. Considering the extreme case—namely, the effect of an impurity consisting of 10 per cent. sinks with 60 per cent. ash—it is seen that pure coal, ash 2 per cent., has its ash content increased to 7·8 per cent., a figure rather high for a normal clean coal, and a high-grade clean coal with 5 per cent. ash has its ash content more than doubled; whereas low-grade fuel, ash 35 per cent., has its ash content increased only to 37·5 per cent. In general, impurities have a less harmful effect on the lower grades of fuel. This latter observation, though based on the effect of impurities with respect to ash content, is largely true in relation to other effects.

The effect of impurities may be summarised thus: *Pure Coal.*—No impurities with 60 per cent. or even 30 per cent. ash are permissible; 1 to 2 per cent. of material just sinking at 1·4 sp. gr. will do little harm, if the ash content of the remainder of the material is sufficiently low. *Normal Clean Coal.*—60 per cent. ash sinks are undesirable, particularly in nut sizes; in fines their presence in very small proportions is not absolutely prohibited; the presence of 3 to 4 per cent. of 30 per cent. ash sinks is not specially injurious. *Medium-Ash Boiler Fuel.*—30 per cent. ash sinks not harmful; up to 5 per cent. of 60 per cent. ash sinks

TABLE II.—EFFECT OF IMPURITIES ON ASH CONTENT.

Sinks.		Ash in Product.							
Ash. Per Cent.	Weight. Per Cent.	Per Cent.							
—	0	1·50	2·00	5·00	10·0	15·0	20·0	25·0	35·0
30	2	2·07	2·56	5·50	10·4	15·3	20·2		
	5	2·93	3·40	6·25	11·0	15·8	20·5		
	10	4·35	4·80	7·5	12·0	16·5	21·0		
60	2		3·16	6·10	11·0	15·9	20·8	25·7	35·5
	5		4·90	7·75	12·5	17·3	22·0	26·8	36·2
	10		7·80	10·5	15·0	19·5	24·0	28·5	37·5
10	2	1·67	2·16						
15	2	1·77	2·26						

permissible. *Low-grade Fuel.*—Unlikely to be seriously depreciated by any probable impurity.

It is now possible to formulate a coal-cleaning policy. Coal-cleaning processes should be applied so as to fulfil one or more of the following conditions:—(1) The process should not be required to operate under conditions in which it is inefficient; (2) if operation under conditions of inefficient working is unavoidable, the

* Paper presented at a meeting of the Institute of Fuel, in London, on Thursday, May 30, 1940. Abridged.

† "Pure Coal," by Dr. E. S. Grumell, *Trans. Inst. Min. Eng.*, vol. 87, page 260.

process should be arranged so that, as far as possible, contamination of the washed products with sinks of higher ash content is confined to products themselves high in ash, and to fines rather than nut sizes; and (3) where the required separation permits, the characteristics of the process which cause inaccurate separation may be used to advantage.

Most pneumatic separators recirculate, as middlings, about 15 per cent. of the raw-coal feed. If a pneumatic separating plant is over-loaded, with the result that the clean coal is too high in ash, these middlings, instead of being recirculated, should be rewashed in a jig or trough washer. The "rewash" middles may either be disposed of separately as a medium-ash boiler fuel or may be added to the pneumatic-separator products. In the latter case, the relatively small proportion of wet coal will not raise unduly the moisture content of the combined products.

There are various fairly simple devices for dealing with moderate overloading. If a jig washer treating a difficult coal is overloaded, and the washed products are unsatisfactory, these should be tried first. If the results are still unsatisfactory, the outlet-end automatic dirt discharge should be adjusted so that the washed coal is satisfactory, even if this entails a loss of coal in the outlet-elevator dirt. The outlet-elevator dirt is rewashed in a small middles rewash box. Usually, the middles will be crushed before rewashing. The fuel recovered from the rewash box will normally have an ash content between 10 per cent. and 15 per cent., and, if desired, may be used as a boiler fuel. Frequently, however, the adjustment of the primary washer box will have the effect of reducing the ash in the washed fines to such an extent that all or part of the relatively small proportion of recovered middles may be mixed with the washed fines.

Experience with this problem of rewashing the outlet elevator dirt from an overloaded box appears to indicate that the proposal offers attractive possibilities. In the first place, an accurate forecast of the probable results of the proposed modifications can be obtained at little or no expense. Secondly, the modifications will normally be relatively inexpensive. Finally, the middles rewash box may be adjusted to recover, not only the loss of coal resulting from the readjustment of the primary box, but also higher-ash middlings of 1·6 to 1·8 sp. gr. normally discarded with the refuse. The fuel recovered from the rewash box, being relatively high in ash, is less affected by impurities than the primary cleans. Even if the recovered middles are mixed with the washed fines the relatively small proportion of this product reduces the harmful effect of impurities.

If a trough washer is considerably overloaded and the washing results are poor, the overloading may be reduced and the washing problem simplified by providing a separate unit for the fraction normally recirculated. The coal recovered by this unit may be partly or wholly utilised as a medium-ash boiler fuel. In a washery combining a dense-medium separator with a jig or trough washer, it is preferred to use the jig or trough washer to handle sizes below approximately ¼ in., thereby avoiding the conditions under which the efficiency of a dense-medium separator is reduced.

The simplest method of producing, from a suitable washed coal with 4 per cent. or 4·5 per cent. ash, a pure coal with 2 per cent. ash for the production of smokeless fuel and a boiler fuel that will command a ready sale, is to treat the washed coal in a small specially-designed jig washer, adjusted to make equal proportions of pure coal and boiler fuel. If the jig is adjusted to make the ash in the pure coal 2 per cent., the ash in the boiler fuel will be 6 per cent. or 7 per cent., according as the ash in the original washed coal is 4 per cent. or 4·5 per cent. This takes advantage of the characteristic of a jig which enables it to produce products that are not graded with respect to specific gravity alone, a characteristic which normally is disadvantageous. The special jig normally operates under conditions in which it is not required to give a particularly accurate separation; consequently it may be relatively small and inexpensive. Moreover, the use of a jig for the preparation of "pure" coal makes it possible to treat fines. So long as a high-grade coal is chosen as the primary product for the production of ultra-clean coal, the method described above will usually give the required separation.

(To be continued.)

THE INSTITUTE OF TRANSPORT.—As no nominations to fill vacancies on the Council arising on September 30, have been received from corporate members of the Institute of Transport by the prescribed date, the following 10 members have been declared to be duly elected as ordinary members of the Council as from October 1: Messrs. A. L. Castleman, G. F. Craven, B. England, S. H. Fisher, C. M. Jenkin Jones, R. Leslie, R. M. T. Richards, V. A. M. Robertson, M.C., J. H. P. Turner, O.B.E., and M. A. Cameron (associate member).

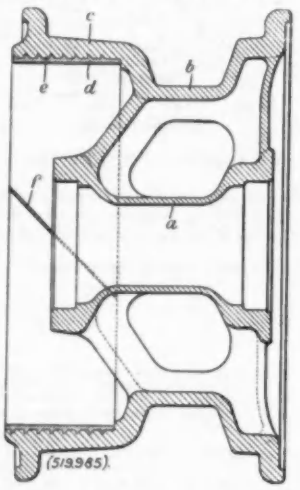
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

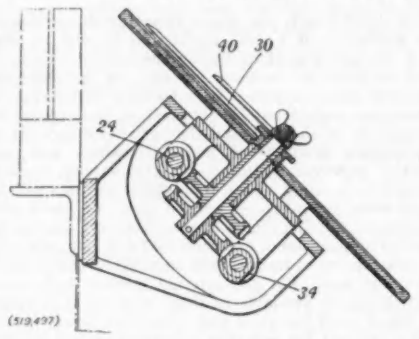
519,985. Aeroplane-Brake Drum. The Midland Motor Cylinder Company, Limited, of Smethwick, and E. C. Toghill, of Smethwick. (4 *Figs.*) October 7, 1938.—The invention is a hard-metal liner for light-alloy brake drums which is not liable to distortion due to the unequal expansion and contraction of the drum and the liner. In the aeroplane wheel shown, the hub shell *a* and rim *b* are integral and the rim has a part *c* which forms the brake drum. The wheel and its drum are made of an aluminium or magnesium alloy and into the drum is fitted a cast-iron liner *d*. The interior of the drum and



exterior of the liner are machined with a buttress screw thread having a fairly steep pitch so that flats *e* are left between the threads to give a good contacting surface for heat conduction. After the thread on the liner has been machined the liner is split by a diagonal saw cut *f* the inner edges of which are then chamfered off. The direction of the screw thread is such that the normal braking torque will tend to screw the liner farther into the drum and the screw threads are of opposite hand on the two sides of the aeroplane. The thread near the inner end of the liner and drum is omitted to avoid a thin knife-edged thread part. The inner end is finished square. (*Accepted April* 11, 1940.)

LIFTING AND HAULING APPLIANCES.

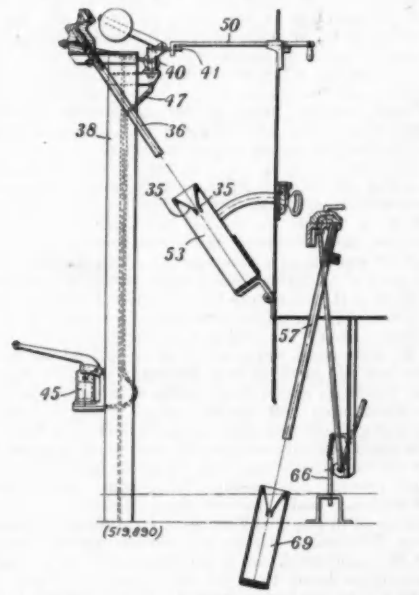
519,497. Dredger-Grab Indicator. Priestman Brothers, Limited, of Hull, and G. B. Oliver, of Hull. (3 *Figs.*) November 4, 1938.—The invention is a tell-tale indicator for grabs which are controlled by an opening and a hoisting or closing rope. When these grabs are used for dredging, the grab is invisible and it sometimes happens that the jaws are closed during descent through the water, and the indicator is therefore designed to show the relative positions of the jaws. The opening drum and the closing drum are of the same diameter and each carries a gear wheel driving a pinion, the respective gear wheels and pinions having the same number of teeth. The pinions are connected by flexible shafts to worms 24, 34 in the indicator, which is mounted in the cab, and drive pointers 30, 40, moving over a dial. The pointer 30 is frictionally mounted on a sleeve so that it can be adjusted, the pointer 40, which is shorter, being also adjustable on its spindle by a butterfly nut. The two worm gears have the same gear ratio, so that when the drums are running at the same speed the two pointers also rotate at the same speed. The dial is marked in feet around its margin. In use, the grab is lowered closed to the surface of the water. The pointer 30 is then set to zero and the grab is opened. When the jaws are fully open, the pointer 40 is made to coincide with the pointer 30. The grab is then lowered and if the closing drum should lag behind the opening drum, thereby tensioning the closing rope, the pointer 40 lags behind the pointer 30 and the operator is warned that the closing rope should be slackened to maintain the grab open. When the pointers have been set as described



above, the reading of the dial will indicate correctly the depth of the finished bite of the grab below water-level, and the relative movement of the two pointers reveals the position of the jaws in relation to one another at all times. (*Accepted March* 28, 1940.)

RAILWAYS AND TRAMWAYS.

519,890. Railway Token Exchanger. The Railway Signal Company, Limited, of London, W. S. Roberts, of Ormskirk, and J. H. Burton, of Liverpool. (2 *Figs.*) October 5, 1938.—The invention is a token-exchange apparatus in which the train staff is passed between train and post by compressed air. This avoids the damage usually inflicted on the staff when mechanical pick-up is used at high train speeds. The projection apparatus beside the track consists of a projection tube 36 mounted on a line-side standard 38, and directed towards the train. The upper end of the projection tube communicates with a compressed-air valve 40, the rotary plug of which is operated by an arm 41 projecting towards the track. Compressed air is supplied by a manual compressor 45, the outlet communicating through a pipe



47 with a pressure-control diaphragm valve loaded by a weighted lever. This valve is opened to connect the pipe 47 and the valve 40 only when a predetermined pressure has been developed in the compressor 45. A horizontal trip arm 50 on the train is moved out to engage the arm 41 of the compressed-air valve. The train carries an elongated receiver 53 with a rubber cushion and rubber flaps 35 which check the momentum of the staff to avoid shock or rebound. In operation, the train-staff is inserted into the breech end of the projection tube and the air compressor 45 is pumped up until the pressure-control valve opens. As the train passes, the trip arm 50 engages the arm 41 and opens the compressed-air valve. Compressed air then passes to the upper end of the tube and the train staff is projected into the receiver 53 on the train. The projecting apparatus 57 on the train is similar to the line-side apparatus, except that the compressed air is derived from the braking system so that a separate compressor is not required. The compressed-air valve is opened by the engagement of an arm 66, which is spring loaded into the closed position, with a trip mounted beside the track. The staff falls into a receiver 69. (*Accepted April* 9, 1940.)